DEPARTMENT OF ENERGY
FY 1999 CONGRESSIONAL BUDGET REQUEST
ENERGY EFFICIENCY AND RENEWABLE ENERGY
ENERGY CONSERVATION
(Tabular dollars in thousands. Narrative in whole dollars)

TRANSPORTATION SECTOR

PROGRAM MISSION

Transportation Energy Situation

Activities funded by the FY 1999 budget for the transportation sector will continue to build the foundation for substantial gains in transportation vehicle fuel economy and use of alternative fuels. The following table provides historical and baseline projection data which illustrate the growing need for action and results in transportation:

	1973	1995	2000	2010	2020
Share of U.S. Oil Imported (%)	36.1	50.4	57.1	65.8	69.2
Ratio of Transportation Oil Use to Domestic Oil Production	0.91	1.69	1.69	2.69	3.16
Number of U.S. Light Vehicles (millions)	120	181.1	184.7	210.1	228.6
Transportation Oil Use (million barrels per day)	8.77	10.96	12.39	14.76	16.13
Net Oil Imports (million barrels per day)	5.99	7.88	10.31	13.74	15.53
Direct Cost of Imported Oil (billions of 1994 dollars)	22	48.1	71.7	104.9	126.6
Transportation Carbon Emissions (million metric tons per year)	N/A	457	518.1	627.5	691.6
New Car Fuel Economy (miles per gallon)	14.2	28.6	28.0	30.3	30.7
New Light Truck Fuel Economy (mpg)	13.7*	20.5	19.3	20.1	21.67

*1975 Estimate

PROGRAM MISSION - TRANSPORTATION SECTOR (Cont'd)

Program Emphasis

The program emphasis is on the development and commercialization of technologies which have the potential to radically alter current trends of United States and world demand for energy, particularly oil. Seventy-six percent of total transportation sector energy consumption is used by on-highway vehicles—cars and trucks. Working in partnership with industry and others, the mission of the Office of Transportation Technologies (OTT) program is to provide consumers with vehicle choices which result in significant oil demand and greenhouse gas emission reductions. Specific strategic objectives are to: (1) improve the fuel economy of transportation vehicles; and (2) increase the production and use of cost-effective alternative transportation fuels.

Industry often organizes for design, production, and marketing of cars and trucks around the idea of vehicle "platforms." "Class" is another term used to describe vehicles having distinctively different characteristics and capabilities. **In DOE's transportation sector program, every activity contributes to fuel economy improvement and/or alternative fuel capability for one or more of the following vehicle "platforms."**

1. Automobiles.

2. Light Trucks, including mini-vans and sport utility vehicles. (Classes 1 and 2)

3. Medium Trucks, such as delivery vans. (Classes 3 through 6)

4. Heavy Trucks, such as inter-city "18-wheelers." (Classes 7 and 8)

The diagram below illustrates how activities funded in the automotive and heavy vehicle portions of the budget are related to these basic vehicle platforms.

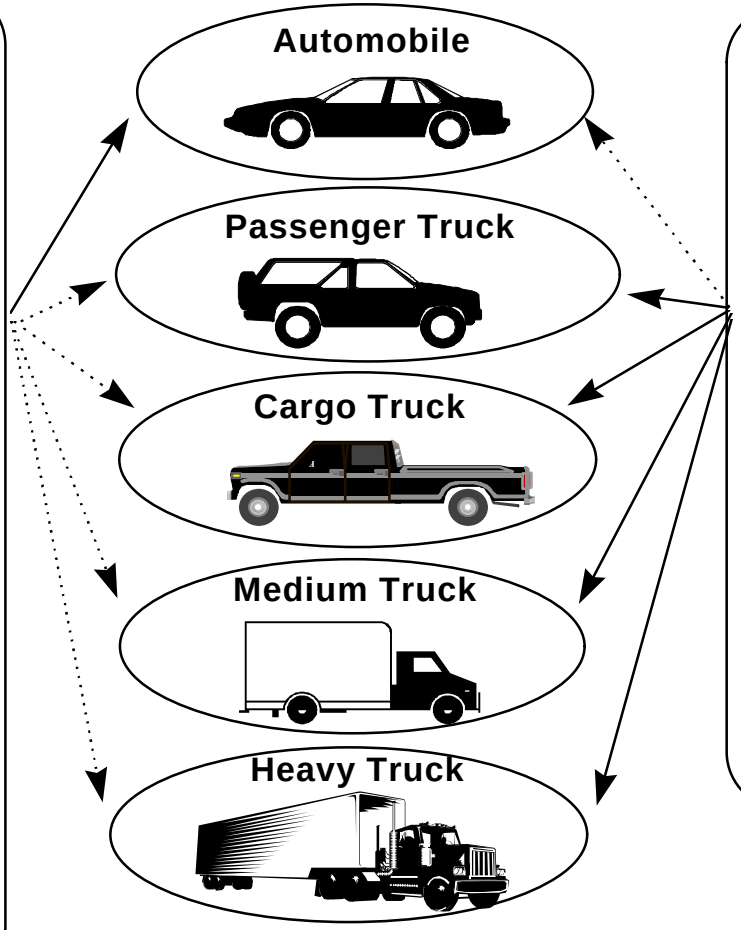
In every portion of the budget which supports technology research and development, each activity is directed primarily at a particular vehicle platform. However, as the diagram indicates, each R&D activity also has potential "spin-off" benefits for other platforms. For example, fuel cell development activities are focused specifically on achieving characteristics required for successful use in automobiles; but advances made could well result in truck and bus applications. The solid lines identify primary targets; dotted lines identify vehicle types which could also be changed based on results from each respective program.

FY 99 Budget Supports Multiple Platforms with Advanced Technologies

Automotive Program

- Alternative Fuels R&D
  - System Optimization
  - Advanced Fuels (DME, DMM)
  - Fuel Dispensing Technologies
  - Fuel Storage
  - Fuel Injection Technologies
- Electric Vehicle R&D
  - Nickel-Metal Hydride Battery
  - Lithium-Based Battery
- Vehicle Systems R&D-Exploratory R&D
  - Systems R&D
  - CIDI, SIDI
  - High Power Storage
  - Advanced Power Electronics
- Fuel Cell R&D
  - Stack Technology
  - Reformer & Storage R&D
  - Fuel Cell Systems R&D
  - Auxiliary Technology R&D
- Advanced Combustion R&D
  - Combustion
  - Emission Controls
  - Engine Technology Integration
- CARAT
  - Innovative R&D on Automotive Technologies (small business & Univ..)
- Advanced Materials
  - Lightweight Metals
  - Composites
  - Carbon Fiber

Platform



Heavy Vehicle Program

- Diesel Engine R&D
  - Diesel Combustion
  - Exhaust Aftertreatment
- Systems Technologies
  - Aerodynamics
  - Auxiliary Systems
- Advanced Transportation Technology Consortia
- Alternative Fuels R&D
  - Engine Efficiency
  - Combustion
  - Atmospheric Reactions
  - Storage Technologies
- Advanced Materials
  - High Temperature Materials Laboratory

PROGRAM MISSION - TRANSPORTATION SECTOR (Cont'd)

In the Technology Deployment portion of the budget, activities support multiple platforms. In most Clean Cities, for example, individuals and organizations involved include purchasers and users of all vehicle types.

Program Benefits

The following benefits are projected from sustained multi-year funding of the transportation program.

Improvements Due to Transportation Programs:	**2000**	**2010**	**2020**
New Car MPG	29.0	39.7	42.9
New Light Truck MPG	20.3	24.6	27.1
Carbon Emission Reductions:			
Million Metric Tons (MMTons)	0.64	26.7	55.2
% Carbon Reduced	0	4.2	9.8
Direct Oil Savings:			
Million Barrels per Day (MBPD)	0.06	1.13	1.97
% Oil Use Reduced	0.5	7.7	12.2
Increased Use of Renewables:			
MBPD Oil Equivalent	0	0.32	0.47

Studies estimate that developing countries will be major markets for technologies supported by this budget. While U.S. and European vehicle sales will grow modestly, sales in developing countries are expected to increase by over five percent annually. This provides a large export market opportunity for America's transportation industry, potentially also leading to the creation of jobs in the U.S.

DEPARTMENT OF ENERGY
FY 1999 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
(Dollars in thousands)

PROGRAM FUNDING PROFILE

Transportation Sector

Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Base	FY 1999 Request	Program Change Request vs. Base Dollar	Program Change Request vs. Base Percent
Advanced Automotive Technologies Operating Expenses	$102,717	$113,296	$113,296	$144,646	$ 31,350	28%
Advanced Heavy Vehicle Technologies Operating Expenses	$ 19,129	$ 25,600	$ 25,600	$ 44,200	$ 18,600	73%
Transportation Materials Technologies Operating Expenses	$ 32,256	$ 35,000	$ 35,000	$ 31,800	$ -3,200	-9%
Technology Deployment Operating Expenses	$ 10,618	$ 11,775	$ 11,775	$ 16,250	$ 4,475	38%
Implementation and Program Management Operating Expenses	$ 7,737	$ 7,600	$ 7,600	$ 9,200	$ 1,600	21%
TOTAL	$172,457 a/ b/	$193,271	$193,271	$246,096	$ 52,825	27%
Summary						
Operating Expenses	$172,457	$193,271	$193,271	$246,096	$ 52,825	27%
Total Program	$172,457	$193,271	$193,271	$246,096	$ 52,825	27%
Staffing (FTE's)						
HQ FTEs	67	60	60	57		
Field FTEs	1	1	1	1		
Total FTEs	68	61	61	58		

PROGRAM FUNDING PROFILE: Transportation Sector (Cont'd)

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a/ Reflects adjustment for approved reprogramming 97-R-12 of $-2,857.8 thousand for the Small Business Innovative Research (SBIR) program and $-225.6 thousand for the Small Business Technology Transfer Pilot Program (STTR) activities.

b/ Reflects adjustment of $+337.0 thousand for approved reprogramming 97-R-15b for Program Direction activities utilizing $-224.0 thousand in prior year balances and $-113.0 thousand from the Industry Sector Program Direction.

Authorizations:

P.L. 93-275, "Federal Energy Administration Act of 1974"
P.L. 93-577, "Federal Nonnuclear Energy Research and Development Act of 1974"
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-413, "Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976"
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 95-238, Title III - "Automotive Propulsion Research and Development Act of 1978"
P.L. 96-512, "Methane Transportation Research, Development and Demonstration Act of 1980"
P.L. 100-494, "Alternative Motor Fuels Act of 1988"
P.L. 102-486, "Energy Policy Act of 1992"

DEPARTMENT OF ENERGY
FY 1999 CONGRESSIONAL BUDGET REQUEST
ENERGY CONSERVATION
(dollars in thousands)

SUMMARY OF CHANGES

Transportation Sector

FY 1998 Enacted	$ 193,271
FY 1999 Base	0
	$ 193,271

Advanced Automotive Technologies

- Automotive Alternative Fuels R&D - The increase reflects the development of alternative and reformulated fuels for compression ignition direct injection (CIDI) engines. In addition, compressed natural gas fueling station cost reduction efforts will be accelerated	1,450
- Electric Vehicle R&D - The decrease is consistent with the overall strategic plan to complete all U.S. Advanced Battery Consortium (USABC) mid-term battery technologies and concentrate efforts on one or more long-term battery technologies	-7,386
- Vehicle Systems R&D - The decrease reflects the completion of the first phase (50 mpg) of the hybrid propulsion system development effort and the start-up of the next phase (80 mpg) of the vehicle systems development which initially consists of modeling, trade-off studies, and conceptual design studies. It also reflects the downselection process which reduces the number of candidate technologies for the next phase of technology development	-200

SUMMARY OF CHANGES: Transportation Sector (Cont'd)

Advanced Automotive Technologies (Cont'd)

- Fuel Cell R&D - The increase reflects critical needs for further component development related to technical barriers such as cold start-up and transient response, power management, thermal management, durability, and reliability. Processes for low-cost, high-volume manufacture of fuel cells and components will be developed . .	21,086
- Advanced Combustion Engine R&D - The increase reflects the characterization of the performance and emissions of advanced CIDI engines fueled with reformulated or alternative fuels	10,400
- Cooperative Automotive Research for Advanced Technologies - The increase will allow DOE to provide opportunities to small businesses and universities for development of advanced components and processes suitable for cost-effective automotive production	6,000

Advanced Heavy Vehicle Technologies

- Heavy Vehicle Systems R&D - The increase supports a joint Government/industry program for the development of clean diesel engine technologies for light trucks, and for transitioning the Advanced Transportation Technology Consortia program from the Defense Advanced Research Projects Agency to a combined DOE/DOT program, with DOE focusing on trucks	20,300
- Heavy Vehicle Alternative Fuels R&D - The decrease reflects a temporary reduction for program restructuring, that includes initiation of new projects	-1,700

Transportation Materials Technologies

- Automotive Materials Technology - The decrease for propulsion system materials reflects the termination of work on ceramics for gas turbines	-2,750
- Heavy Vehicle Materials Technology - The decrease reflects reduced work in two major projects, i.e., carbon products for heavy vehicle applications and casting of ultra large heavy vehicle components	-750
- High Temperature Materials Laboratory - The increase supports investment in improved technological capability for the characterization of advanced materials	300

SUMMARY OF CHANGES: Transportation Sector (Cont'd)

Technology Deployment	
- Clean Cities Voluntary Deployment - The increase reflects an expanded Clean Cities program and expanded State grants, that will both feature advanced fuel efficient vehicles.	3,150
- Infrastructure, Systems, and Safety - The decrease reflects reduced funding as a result of completion of selected electric vehicle infrastructure products	-175
- EPACT Replacement Fuels Program - The decrease reflects reduced funding due to the completion of Energy Policy Act reports	-100
- Vehicle Field Test/Evaluation - The increase reflects the addition of hybrid vehicle field testing, and the integration of electric vehicle and alternative fuel vehicle testing programs	600
- Technical Information Development - The increase reflects expanded and enhanced information products to encourage the use of fuel efficient vehicles	1,000
Implementation and Program Management	
- Evaluation, Planning and Analysis - The increase reflects an expanded quality metrics methodology, to include international impacts	800
- Program Direction - The increase provides for pay raise adjustments in salaries and benefits, and for training and other services, while supporting the Department's Strategic Alignment Initiative to streamline the management of research, development, demonstration and deployment programs within the Office of Transportation Technologies	800
FY 1999 Congressional Budget Request	$ 246,096

TRANSPORTATION TECHNOLOGIES

TRANSPORTATION SECTOR
(dollar in thousands)

ADVANCED AUTOMOTIVE TECHNOLOGIES

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission

The Advanced Automotive Technologies program is the technological cornerstone for the nation's initiative to significantly improve the energy efficiency of, and reduce emissions from, our light duty vehicles, with a direct emphasis on automobile applications. An updated R&D Plan for the Office of Advanced Automotive Technologies defines the scope, focus, and content of the Advanced Automotive Technologies program. This R&D Plan has been developed through an intensive activity involving experienced teams of DOE and national laboratory personnel, working in a collaborative process to structure and focus the Department's effort. Plan development has included participation of stakeholders such as the auto industry and its supplier companies, energy companies, State and other Federal agencies, and other DOE organizations.

This Advanced Automotive Technologies program provides the primary support for research and development required to achieve the 80 miles per gallon (mpg) fuel economy goal of the Partnership for a New Generation of Vehicles (PNGV). This work is important because automobiles are 97 percent dependent upon petroleum-based fuels and consume about 33 percent of the total petroleum used in the United States, of which 50 percent is imported. Furthermore, the automobile is a major contributor to emissions of global climate change gases and criteria air pollutants, including volatile organic compounds, nitrogen oxides, carbon monoxide, and particulate matter. The current status of technology allows many opportunities, but also tremendous challenges, for improvement. For example: current baseline engine efficiencies are about 23 percent--program targets would more than double this efficiency; current energy storage technologies limit advanced vehicle driving ranges--the program seeks to develop electric vehicle batteries and other technologies that would enable ranges equal to those of conventional vehicles.

Through this program, the Department engages the technical and financial resources of the government and its laboratories, the automobile and fuels industries, their suppliers, and universities in a customer-focused national program to research and develop advanced automobile technologies, and to support their integration into affordable vehicles. Through partnering with industry, critical components and vehicle system technologies are identified and developed that will enable successful commercialization of electric and hybrid vehicles in the mid term, and fuel cell-powered vehicles in the longer term. With program success, pre-production prototype vehicles that provide up to 100 percent greater fuel economy will be available by the year 2001; in the longer term (2005-2010), automobiles that have three times the fuel economy of today's conventional automobiles will be developed. Successful development

I. **Mission Supporting Goals and Objectives**: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

of these technologies will also result in vehicles with near-zero emissions and enhanced fuel flexibility, and which are otherwise competitive in all respects with conventional products in the global marketplace.

The key elements of the program include: Automotive Alternative Fuels R&D, aimed at reducing dependence on petroleum through the use of alternative transportation fuels; Electric Vehicle R&D, focused on development of advanced batteries that meet stringent technical and cost goals, and would enable U.S. industry to market electric vehicles which compete directly with conventional vehicles, and which can expand its market share in response to agreements with the States on zero-emission vehicles; Vehicle Systems R&D, which sets targets for and develops advanced propulsion subsystems and critical components to achieve fuel economy objectives; Fuel Cell R&D, which will continue component development, testing and cost reduction for a propulsion technology with the potential for even higher energy conversion efficiency and near-zero total fuel cycle emissions; and Advanced Combustion Engine R&D, aimed at significantly improving the energy conversion efficiency of traditional combustion engines (including those using alternative fuels) and simultaneously reducing emissions, while advancing the technology base. In many cases, programs are closely coordinated with related efforts of other organizations. For example, compression ignition direct injection technology development for the PNGV is tightly coordinated with activities funded by the Advanced Heavy Vehicle Technologies program; several projects that address technologies applicable to both automobiles and trucks are jointly funded by the two Office of Transportation Technologies (OTT) organizations.

I. B. Program Benefits

Metric*	2000	2010	2020
Primary Energy Displaced (Quads)	0	0.23	1.08
Primary Oil Displaced (million barrels per day)	0.01	0.246	0.72
Energy Cost Savings ($ billion)	0.8	3.99	12.72
Carbon Reductions (million metric tons)	0	3.62	19.08

*Includes benefits for automotive materials.

Research and development activities funded by the alternative fuels program will help the private sector complete the development of commercially attractive ethanol fueled passenger cars. In addition, work on lower cost, higher capacity natural gas on-board storage systems will help promote the use of that alternative fuel.

As a result of Electric Vehicle R&D activities, it is expected that electric vehicles with advanced mid-term batteries, which will double the approximately 70-mile vehicle range obtained by using conventional lead-acid batteries, will begin to enter the market in 1999-

2000. Introduction of long-term advanced batteries, which could power electric vehicles with a range comparable to conventional vehicles by the year 2001, will result in oil savings of 5,000 barrels per day (bpd) in 2002, growing to 150,000 bpd in 2010 as market penetration increases to 2.7 percent.

As a result of Vehicle Systems R&D activities, it is expected that hybrid vehicles will begin to enter the market in large volumes between 2003 and 2010. Continued market penetration will result in oil savings of 369,000 bpd in 2020.

As a result of R&D funded by the fuel cell program, it is expected that vehicle fuel cell technology will begin to enter the market in 2008. This will result in small savings in 2010. However, by 2020 it is estimated that the benefits of the program will be 103,000 barrels per day of oil reduction, $2.0 billion in energy cost savings, and 4.1 million metric tons of carbon-equivalent emissions reduction.

The primary benefits of Advanced Combustion Engine R&D activities will accrue through the application of compression ignition direct injection (CIDI) engine technology to hybrid propulsion automobiles. Additional benefits will result from the application of CIDI engine technology in conventional vehicles, which are estimated to reach 62,000 barrels per day of oil reduction annually, and over $1.3 billion of energy cost savings, by 2010.

I. C. Performance Goals

Strategy/Goal: By 2010, in collaboration with U.S. auto industry partners, produce technologies that lead to vehicles in production which are up to three times more fuel efficient than today's vehicles, and which will reduce nitrogen oxides and carbon dioxide emissions by two-thirds compared to today's new car average without compromising safety, comfort, and cost. Also, these technologies will make the battery-powered electric vehicle an attractive and preferred option for many vehicle users.

Interim Goal: By the year 2000, complete development of production feasible hybrid propulsion systems that can double the fuel economy of passenger vehicles, compared to 1995 models, by all three of the United States' major auto manufacturers. Continuing work on propulsion systems and energy storage will be combined with advanced lighter weight vehicle structures to meet the PNGV goal of 80 miles per gallon, for a production prototype, in 2004. The United States Advanced Battery Consortium (USABC) will have demonstrated long-term battery technology in electric vehicles that are competitive with conventional vehicles in all respects.

FY 1997 Accomplishments

-- Completed the fabrication and field evaluation of dedicated propane and ethanol fueled sedans which meet ultra low emission vehicle (ULEV) standards.

-- Achieved the mid-term goal of 80 watt-hours/kilogram (Wh/kg) specific energy for nickel metal hydride batteries.

I. Mission Supporting Goals and Objectives: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

-- Completed the first round of laboratory tests on long-term lithium polymer battery modules, to enable the industry to evaluate in-vehicle operation.

-- Completed fabrication of a Stirling powered test-bed vehicle with advanced hybrid propulsion systems for testing and technology validation.

-- Made selection of the engine and energy storage technologies to be integrated into deliverable hybrid vehicles.

-- Evaluated test-bed vehicles using an off the shelf compression ignition direct injection (CIDI) engine to refine the system operating strategy and optimize driveability; finalized the hybrid propulsion package design, and completed development of balance of drivetrain components.

-- Completed testing of four baseline prototype high power battery cells, and selected two baseline technologies for development of 50-volt prototype modules aimed at satisfying high power battery requirements of hybrid vehicles.

-- Completed development of an aqueous tape-casting process for components of a planar oxygen sensor for automobile exhaust gas measurement.

-- Completed laboratory validation tests on a methanol-fueled 30 kW proton exchange membrane fuel cell propulsion system.

-- Demonstrated 40 miles per gallon (combined city-highway cycle) on a mid-size vehicle in the FutureCar Challenge.

-- Completed the second series of improved power electronic building block (PEBB) modules using pre-production inverter/converter products, to achieve a 50 percent reduction in cost, weight, and volume.

FY 1998 Planned Accomplishments

-- Complete the lower cost, lighter weight natural gas cylinder project for on-board storage. Complete determination of requirements for reduced cost and increased reliability of alternative fuels refueling (dispensing) hardware.

-- Begin extensive laboratory testing of long-term electric vehicle lithium polymer batteries which would provide 3 to 4 times the range, and significantly greater performance and life, compared to conventional lead acid batteries.

-- Complete the development of a production feasible hybrid propulsion system which can double vehicle fuel economy, and integrate the propulsion system into two vehicles for independent testing; with the second and third industry hybrid teams, complete testing of final deliverable components and assemble propulsion systems for testing in test-bed vehicles.

I. Mission Supporting Goals and Objectives: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

-- Fabricate 50-volt nickel metal hydride high power modules and initiate life cycle testing.

-- Scale up high power energy storage lithium-ion technology from one to 12 ampere-hour size cells.

-- Develop abuse test requirements and protocols, and complete assessment of high power energy storage lithium-ion safety performance envelope.

-- Complete PEBB technology laboratory tests that demonstrate the potential for 75 percent reduction in cost, weight, and volume relative to 1995 baseline.

-- Initiate Phase II of the hybrid vehicle systems program: development of enabling technologies capable of achieving an 80 mile per gallon (mpg) passenger vehicle.

-- Complete laboratory validation tests on hydrogen-fueled 50 kW (full-scale) proton exchange membrane fuel cell propulsion systems that can be tested under automotive drive cycle requirements.

-- Demonstrate 45 mpg (combined city-highway cycle) in the FutureCar Challenge.

-- Introduce a new Ethanol Challenge and demonstrate improved cold start capability of dedicated E-85 vehicles.

-- Commence prototype testing at the compression ignition direct injection (CIDI) engine benchmarking facility.

-- Complete data correlation from single cylinder, optical access and non-optical access CIDI engine tests.

FY 1999 Planned Accomplishments

-- Complete development of an optimized prototype dimethyl ether (DME) injection system for CIDI engine.

-- Initiate life cycle testing of advanced electric vehicle lithium polymer batteries and assess performance against USABC long-term battery goal of 1,000 cycles.

-- Complete international cooperative development of lithium battery safety abuse test and procedures manual.

-- Define vehicle design concepts capable of achieving 80 mpg. Focus will be on systems analyses, trade-off studies, and data gathering to determine optimum design for achieving program goals. Initiate a hardware design and integration effort.

I. Mission Supporting Goals and Objectives: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

-- Complete 50-volt high power energy storage lithium-ion module development; initiate performance characterization and life cycle testing at the DOE laboratories; and compare results to PNGV technical targets of 25 watts per watt-hour (W/Wh) power-to-energy ratio, 60 watt-hours per liter (Wh/l) energy density, and 125,000 cycles.

-- Integrate power electronic building block (PEBB) technology into pre-production vehicles; demonstrate achievement of PEBB technical targets of $7/kW cost, 12 kilowatts per kilogram (kW/kg) specific power, and 96 percent efficiency.

-- Demonstrate 80 mpg fuel efficiency on the combined driving cycle on mid-sized sedans in the advanced technology competitions programs.

-- Demonstrate improved energy efficiency and reduced emissions from dedicated E-85 vehicles in the second year of the Ethanol Challenge.

-- For fuel cell vehicles, develop and test an advanced, high-efficiency, 50 kW, fuel-flexible fuel processor demonstrating a system efficiency of 70 percent and a start-up time less than 3 minutes.

-- Validate, by engine dynamometer testing and simulation of vehicle systems, advanced piston engine technology that meets requirements for an 80 mpg, low emissions automobile.

-- Test and evaluate nonthermal plasma-activated catalyst prototype for CIDI engines, with the potential to significantly reduce emissions.

-- Validate CIDI catalytic nitrogen oxides reduction prototype for year 2000 concept vehicle.

FY 2000 - FY 2004 Planned Accomplishments

-- Complete lower cost alternative fuel refueling technology development.

-- Conduct extended testing of USABC long-term lithium polymer batteries for life and safety under accident conditions.

-- Validate advanced powertrain components for 80 mpg vehicles through performance testing and simulation.

-- Complete testing of baseline, prototype, 50-volt high power lithium-ion modules. Select one or two of the baseline technologies for development of 400-volt battery aimed at satisfying the PNGV high power energy storage requirements of hybrid vehicles.

-- Validate integrated PEBB technology having cost, specific power, and efficiency, necessary to achieve PNGV 80 mpg vehicle goals.

I. Mission Supporting Goals and Objectives: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

-- Develop an integrated, 50 kW (vehicle-size) fuel cell propulsion system that includes a fuel-flexible on-board fuel processor, compressors/expanders, heat exchangers, controls, and sensors, and demonstrates a stack system efficiency of 55 percent at 25 percent of peak power.

-- Complete selection of CIDI fuel injection system (<$8/kW) and fuel for year 2004 production prototype vehicles.

-- Validate CIDI engine system achievement of Tier II emission levels.

II. A. Funding Table: ADVANCED AUTOMOTIVE TECHNOLOGIES

Program Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Automotive Alternative Fuels R&D	$ 3,160	$ 5,550	$ 7,000	$ 1,450	26%
Electric Vehicle R&D	17,497	18,386	11,000	-7,386	-40%
Vehicle Systems R&D	53,840	58,200	58,000	-200	0%
Fuel Cell R&D	20,760	23,560	44,646	21,086	89%
Advanced Combustion Engine R&D	7,460	7,600	18,000	10,400	137%
Cooperative Automotive Research for Advanced Technologies	0	0	6,000	6,000	>999%
Total, Advanced Automotive Technologies	$ 102,717	$ 113,296	$ 144,646	$ 31,350	28%

II. B. <u>Laboratory and Facility Funding Table</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES

	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Argonne National Lab (East)	$ 7,187	$ 8,349	$ 10,349	$ 2,000	24%
Brookhaven National Lab	500	336	500	164	49%
Idaho National Engineering and Environmental Lab	1,175	926	2,000	1,074	116%
Lawrence Berkeley National Lab	3,242	3,400	3,800	400	12%
Lawrence Livermore National Lab	1,303	1,165	2,180	1,015	87%
Los Alamos National Laboratory	4,212	3,837	8,837	5,000	130%
National Renewable Energy Lab	36,776	36,776	43,526	6,750	0%
Oak Ridge National Lab	3,740	6,360	8,050	1,690	27%
Pacific Northwest National Lab	1,285	1,350	1,550	200	15%
Sandia National Laboratories	4,765	4,095	5,000	905	22%
All Other	38,532	46,702	58,854	12,152	26%
Total, Advanced Automotive Technologies	$ 102,717	$ 113,296	$ 144,646	$ 31,350	38%

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES

Activity	FY 1997	FY 1998	FY 1999
Automotive Alternative Fuels R&D	SYSTEMS OPTIMIZATION: Completed the fabrication and field evaluation of two light duty vehicles which incorporate the use of ethanol and propane and meet ultra low emission vehicle (ULEV) standards.	SYSTEMS OPTIMIZATION: Complete evaluation of data and disseminate results of ethanol and propane vehicle test program. Conduct alternative fuel vehicle R&D to increase vehicle performance while lowering costs.	SYSTEMS OPTIMIZATION: Conduct R&D for alternative fuel vehicles that will reduce cost, increase range and fuel efficiency while meeting emission standards. Typically cost share projects at 80% government and 20% industry.
	Compressed Natural Gas (CNG): Completed Phase I (storage) and II (engine) of the advanced natural gas vehicle project. Continued to develop low cost, lightweight storage for natural gas.	Compressed Natural Gas (CNG): Complete the Phase III fabrication and field evaluation of a second generation advanced natural gas vehicle. Complete a lower cost and lighter weight natural gas cylinder project using conventional materials for type 2 tanks which have metal liners reinforced with hoop-wrapped continuous filaments (usually fiberglass) in a resin matrix. Formulate a program to develop low cost storage for natural gas vehicles with new lightweight materials, improved manufacturing techniques, fuel storage integration research, and a test method for on-vehicle tank inspection for natural gas cylinders.	Compressed Natural Gas (CNG): Continue development of lower cost tank material, and cost-effective tank manufacturing techniques, for storage of compressed natural gas for type 4 tanks. These tanks are made with plastic liners with full-wrapped continuous fiberglass and/or carbon fibers in a resin matrix. Begin work on advanced CNG storage concepts. Direct the work toward reaching the targets of $3,000/vehicle for incremental cost and 300 mile range by the year 2000. Focus CNG fueling infrastructure program on reduced cost and increased reliability of compressors and auxiliary equipment, with the goal of reaching cost reduction of 50% from today's costs by 2003. Continue development of high efficiency components for use in

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Alternative Fuels R&D (Cont'd)			natural gas vehicles. Develop improved fuel injectors and ignition systems to reach efficiency gains of at least 5% over current levels by the year 2000. Coordinate with the Advanced Heavy Vehicle Technologies program.
	Ethanol: Complete development of cold-start technology project for ethanol vehicles.	Ethanol: Evaluate and integrate additional cold-start techniques for alcohol fueled engines. Conduct a study to determine the best approach for a high efficiency ethanol vehicle powered by lean-burn spark ignition or four stroke direct injection, and formulate plan to develop a high efficiency ethanol vehicle.	Ethanol: Continue to integrate and evaluate previously developed cold-start devices for alcohol fueled engines, to meet the goal of operation at -20 degrees Celsius. Develop high efficiency components for use in ethanol fueled engines to increase efficiency by 8% in the year 2000.
	Fuels for Advanced Engines: Continued assessment of alternative fuels for four stroke direct injected engines. (NREL, Southwest Research Institute (SwRI)) ($2,310)	Fuels for Advanced Engines: Evaluate potential dimethyl ether (DME) fuel storage systems and develop a DME fuel injection system for use in an automotive diesel cycle engine. Initiate development of a second pump design concept for a DME fuel injection (FI) system. Evaluate commercially available lubricants to determine their adequacy for the DME FI system. Initiate	Fuels for Advanced Engines: Complete development of an optimized prototype DME fuel injection system to be used in an automotive CIDI engine. Perform comprehensive analysis of DME fuel production, distribution, and dispensing requirements, and develop a prototype refueling system. Continue to optimize fuels for use in CIDI engines, and other advanced automotive power

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Alternative Fuels R&D (Cont'd)		testing of advanced fuels on advanced compression ignition, direct injection (CIDI) engines. (Johns Hopkins Univ., SwRI, NREL, TBD) (PNGV: $4,700) ($4,700)	plants. Coordinate with the Advanced Heavy Vehicle Technologies program. (Johns Hopkins Univ., NREL, ANL, ORNL, and TBD) (PNGV: $6,000) ($6,000)
	STUDENT COMPETITIONS: Sponsored and conducted two major competitions, and provided support to one other. Conducted the second year of the FutureCar Challenge, in partnership with Ford, GM, and Chrysler. FutureCar provided universities the opportunity to contribute to the PNGV technology development path and to demonstrate selected systems and technologies in actual on-road vehicles. Also conducted the second year of the Propane Vehicle Challenge in conjunction with the Texas Railroad Commission, Texas State Energy Conservation office, and Chrysler. Added twelve new schools to convert pickup trucks donated by Chrysler. Continued to collect and analyze performance data on various hybrid and alternative fuel	STUDENT COMPETITIONS: Offer new universities the opportunity to participate in the FutureCar Challenge. Provide the opportunity for two FutureCar universities to build fuel cell vehicles. Transition from the Propane Challenge to the Ethanol Vehicle Challenge, co-sponsored by GM. (ANL, ASEE, universities) (PNGV: $850) ($850)	TECHNOLOGY COMPETITIONS: Continue the FutureCar Challenge with enhanced performance targets. Provide limited advanced technologies (e.g., fuel cells) to those universities which demonstrate the greatest potential. Offer opportunities to new universities to participate in the Ethanol Challenge with particular emphasis on hot/cold start capabilities. DOE funding will continue to be matched at least three to one by other contributors. (ASEE, ANL, universities) (PNGV: $1,000) ($1,000)

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Alternative Fuels R&D (Cont'd)	configurations for fuel efficiency, emissions, and performance. Each Federal dollar was matched at least three to one by outside sponsors. In addition, provided support to the American Tour de Sol, conducted by the Northeast Sustainable Energy Association. (American Society for Engineering Education (ASEE), universities, ANL) ($850)		
	$ 3,160	$ 5,550	$ 7,000
Electric Vehicle R&D	ADVANCED BATTERY DEVELOPMENT: Development of advanced batteries that satisfy the long-term performance and cost goals established by the United States Advanced Battery Consortium (USABC) is considered by the automotive industry to be a critical step toward broad consumer acceptance of zero emission vehicles. Continued support for R&D on advanced batteries for electric vehicles through a cost-shared cooperative agreement with the USABC, with industry cost share of 55% in FY 1997.	ADVANCED BATTERY DEVELOPMENT: Continue support for R&D on advanced batteries for electric vehicles with the USABC, with an average industry cost share for Phase II of 55% in FY 1998.	ADVANCED BATTERY DEVELOPMENT: Continue support for R&D on long-term advanced batteries for electric vehicles with the USABC, with an average industry cost share of 55% in FY 1999.

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Electric Vehicle R&D (Cont'd)	Mid-term Battery R&D: Completed R&D efforts to reduce the cost of the mid-term nickel metal hydride battery. Continued test and evaluation program for nickel metal hydride pilot line modules.	Mid-term Battery R&D: Continue test and evaluation program for nickel metal hydride pilot line modules and nickel metal hydride cost-reduction technology programs.	Mid-term Battery R&D: Complete test and evaluation program for nickel metal hydride pilot line modules and nickel metal hydride cost-reduction technology programs.
	Conducted supporting R&D, and performance and life testing of prototype cells, modules, and battery packs, at DOE laboratories under Cooperative Research and Development Agreements (CRADAs) with the USABC. Delivered laboratory test results to the USABC and DOE for detailed evaluation, to establish that progress is being made toward achieving the program goals.	Continue to conduct performance and life testing, with industry and DOE laboratories, under suitable subcontracts or CRADAs. Continue to deliver latest laboratory test results to USABC and DOE for detailed evaluation, to establish that progress is being made toward the program goals.	Continue to conduct performance and life testing and evaluation with industrial developers and DOE laboratories. Complete delivery of laboratory test results to USABC and DOE.
	Continued environmental, safety, and health (ES&H) work on the long-term battery technology selected for development by the USABC, to ensure that these new battery systems will be in full compliance with regulatory requirements when commercialized.	Continue ES&H work on the USABC's selected battery technology, to ensure that these new battery systems will be in compliance with regulatory requirements when commercialized.	Continue ES&H assessment activities on selected advanced battery technology issues through the Advanced Battery Readiness Working Groups, to ensure compliance with regulatory requirements when commercialized.

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Electric Vehicle R&D (Cont'd)	Long-term Battery R&D: Selected a single lithium-based technology with one major developer, for continued R&D to meet USABC long-term goals. Finalized the battery design and fabricated prototype battery systems for evaluation by DOE laboratories and the automotive industry in its prototype electric vehicles. (ANL, INEEL, NREL, USABC) ($15,021)	Long-term Battery R&D: Through the USABC, continue to support work on the long-term advanced lithium-based battery with one major development team. Evaluate first generation prototype batteries in DOE laboratories and by the automotive industry in prototype electric vehicles. Focus technology development on design and manufacturing improvements to reduce costs and improve battery performance and life. (ANL, INEEL, LBNL, NREL, SNL, USABC) ($15,150)	Long-term Battery R&D: Through the USABC, using USABC long-term battery goals, evaluate second and third generation battery packs in automotive industry prototype vehicles. Evaluate option of developing ambient-temperature, lithium-based, long-term battery technologies and compare results to the advanced USABC lithium polymer baseline technology. Focus technology development on manufacturing and enhanced processing to improve battery performance and life and reduce costs. ANL, INEEL, LBNL, NREL, SNL, USABC) ($7,000)
	EXPLORATORY TECHNOLOGY RESEARCH: Continued close cooperation with the USABC and the battery developers within the Exploratory Technology Research (ETR) program. Continued to fund fundamental and applied research on critical areas of advanced battery technology. Selected research areas and coordinated with the USABC and DOE's	EXPLORATORY TECHNOLOGY RESEARCH: Continue research that strives to solve the most difficult problems facing the various vehicle electrochemical powersource systems under development by USABC and Partnership for a New Generation of Vehicles (PNGV) contractors. Focus on clear technical challenges requiring the development of new	EXPLORATORY TECHNOLOGY RESEARCH: Continue to focus exploratory technology research on developing low cost components and processes amenable to mass production of battery technology that can meet USABC and PNGV performance and cost targets. This effort will take advantage of expertise at DOE laboratories, universities, and industries to

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Electric Vehicle R&D (Cont'd)	Basic Energy Sciences (BES) program to maximize the impact on emerging battery technology for electric and other advanced vehicles. Focused on technologies to improve the performance of lithium and lithium carbon electrodes for both high energy and high power batteries. Shared research results with developers working for the USABC and automotive industry. (LBNL, LANL, LLNL, USABC) ($2,476)	processes and components for advanced batteries. Identify new electrochemical power sources for electric and hybrid vehicles that can meet long-term electric vehicle performance and/or cost goals, and can meet the power and lifetime requirements for high power applications. Improve each power source system by better defining the life-limiting processes that are poorly understood; developing significantly better models and analytic tools and applying them to solve critical problems; using advanced analytic techniques on corrosion processes; and developing and optimizing high performance electrochemical components, such as electrodes, electrolytes, and current collectors. (ANL, LANL, LLNL) ($3,236)	solve critical problems via a multi-disciplinary approach. Develop new electrodes, separators, components, and analytical techniques for investigating phenomenological processes. Develop improved understanding of life-limiting and performance-limiting processes. Develop refined user-friendly models and analytic tools to guide the development of lithium-based battery systems. Develop lithium batteries with greater stability and aqueous batteries with the optimal performance-durability/cost ratios. Investigate and characterize thin-film electrodes to understand the relationships of rate controlling mechanisms for the production of power and energy. Characterize and assess thermal behavior of lithium-based systems under dynamic loads--especially high power pulse charges and discharges. Measure transport properties of non-aqueous electrolytes by Nuclear Magnetic Resonance (NMR) techniques to facilitate the development of highly conductive electrolytes. Increase the

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Electric Vehicle R&D (Cont'd)			conductivity of polymer electrolytes by a factor of ten while doubling the energy and power densities of the lithium-based system. (ANL, LANL, LLNL, LBNL) ($4,000)
	$ 17,497	$ 18,386	$ 11,000
Vehicle Systems R&D	Vehicle systems R&D utilizes results of research conducted under all Advanced Automotive Technologies (AAT) budget elements (Hybrid Propulsion Systems, High Power Energy Storage, Heat Engines, Advanced Power Electronics, Advanced Combustion Engine R&D, Lightweight Materials, Alternative Fuels R&D, and Fuel Cell R&D) to resolve integration issues and improve technology to meet program performance targets.	Vehicle systems R&D utilizes results of research conducted under all AAT budget elements to resolve integration issues and improve technology to meet program performance targets.	Vehicle Systems R&D: Vehicle systems R&D utilizes results of research conducted under all AAT budget elements to resolve integration issues and improve technology to meet program performance targets.
	HYBRID PROPULSION SYSTEMS: Continued the development of production feasible hybrid technologies and systems including batteries, power units, controls, and complete electric drive systems	HYBRID PROPULSION SYSTEMS: Continue final development stages of production feasible automotive hybrid propulsion technologies. Fabricate next generation hybrid components and integrate into	HYBRID PROPULSION SYSTEMS: Continue development and further advanced component integration for achieving triple fuel economy.

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	aimed at achieving 50 miles per gallon (mpg) when used in production vehicles. Efforts focused on integrating hybrid technologies into test-bed vehicles for functionality, packaging efficiency, and reliability. Developed control strategies for optimal hybrid propulsion system efficiency and performance under all types of operating conditions. Completed initial testing of components in the laboratory and in the test-bed vehicles. Retained under the prime contracts only those subcontractors which could reasonably support volume production of the most promising technologies. Eliminated technologies for which technical risk and level of maturity did not meet the reliability, cost, and manufacturability targets for the 50 mpg program. For the technologies that were retained, evaluated design improvements to reduce costs and manufacturability, and incorporated the most promising into next generation hardware designs for testing.	test-bed vehicles to assess propulsion system configurations, design approaches, control strategies, and performance under various operational conditions and test cycles. These test-bed vehicles resemble the final deliverable vehicles under the program in form, fit, and function. Focus efforts to refine and improve propulsion system integration, control strategies, and reliability on the development activity. Use propulsion system test data to validate models of predicted performance. Transition the hybrid propulsion R&D activities from a propulsion system development focus, to encompass vehicle development which will be systems driven and barrier focused to achieve the 80 mpg goal. Through systems modeling, begin evaluating the spectrum of technology options including lightweight materials, improved accessories, lower aerodynamics and rolling resistance losses, advanced power electronics, electric motors, transmissions, advanced compression ignition direct	Continue developing and refining the vehicle systems modeling activity to include cost, vehicle handling, and reliability models. Perform trade-off studies to determine the candidate technologies, configurations, and control strategies required to achieve the PNGV 80 mpg fuel efficiency, emission, and cost goals. Improve understanding of performance targets and system requirements for technologies being developed in the program. Develop concept designs that can achieve the goals of the program.

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	(NREL, GM, Ford, ANL, INEEL, Chrysler, Stirling Thermal Motors, AlliedSignal, Detroit Diesel Corp., and others) (PNGV: $38,007) ($38,007)	injection engines, and fuel cells to determine the best possible candidate technologies that have the potential for meeting the performance and cost goals of the program. Initiate a vehicle systems integration effort which will design and fabricate test-beds to evaluate advanced technologies in the context of a lightweight, PNGV-type vehicle. Initiate focused R&D projects aimed at overcoming the critical barriers to commercialization of high efficiency hybrid technologies. Continue systems analysis work with the PNGV partnership under a cooperative agreement with USCAR. (ANL, NREL, INEEL, GM, Ford, Chrysler, subcontractors TBD) (PNGV: $44,700) ($44,700)	Initiate complete hardware designs and begin development and fabrication of the most promising designs through the systems integration effort. Further refine and improve efficiency, cost, weight and volume of the most promising propulsion system technologies for the 80 mpg target. Simultaneously harvest, as appropriate, advanced enabling technologies in other Advanced Automotive Technologies program elements for development in the context of the vehicle systems program. (NREL, INEEL, GM, Ford, Chrysler, subcontractors TBD) (PNGV: $25,000) ($25,000)
	HEAT ENGINE R&D: Continued to focus the gas turbine hybrid power unit and technology support program on four critical turbine engine technologies: structural ceramic component reliability and durability; low emission combustion concepts and control; low cost heat	HEAT ENGINE R&D: Complete the hybrid vehicle gas turbine engine-technology support and ceramic turbine engine demonstration projects. As a result of program restructuring started in FY 1996, conclude both projects when prior year (FY 1997) funding expires. Based on	HEAT ENGINE R&D: Focus the heat engine program on component technology for direct injection engines, including lean-burn gasoline direct injection (GDI), to achieve stringent emissions requirements (.2g/mile nitrogen oxides, .01g/mile particulates) in an advanced, high

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	recovery systems; and hot flow path thermal management and insulation. Continued the ceramic turbine engine demonstration project to demonstrate reliability and durability of ceramic components in modified existing hybrid power units, and demonstrate ceramic component manufacturing processes in the production environment. (Allison, AlliedSignal, ANL) (PNGV: $4,833) ($4,833)	PNGV technology selection decision, no additional turbine-related hybrid power unit R&D will be funded. ($0)	efficiency engine. Develop fuel delivery systems (pumps, injectors) for high compression ratio GDI engines utilizing low sulfur fuel. Develop advanced variable timing technology for direct injection. Apply optical engine measurements to benchmark and compare existing GDI engines to determine characteristics and necessary design features for an optimized GDI engine. Investigate basic fundamentals of GDI stratified charge combustion, determining the importance of in-cylinder mixing, flame quench and propagation as contributions to nitrogen oxides and carbon formation. Conduct single cylinder testing using technology developed under Advanced Combustion Engine R&D program activities. (TBD Consortium: engine manufacturer(s) and suppliers, with ORNL, ANL, TBD universities, TBD other, and USCAR) (PNGV: $13,000) ($13,000)
	HIGH POWER ENERGY STORAGE: High power energy	HIGH POWER ENERGY STORAGE: Under the	HIGH POWER ENERGY STORAGE: Under the

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	storage devices are one of the performance-limiting subsystems in the hybrid vehicle program. Selected the most promising high power battery technologies for further development under the 50% cost-shared cooperative agreement with the U.S. Advanced Battery Consortium (USABC). Focused research and development activity on improving the power density, cycle life, and charge acceptance of the candidate technologies, to achieve capability of high power performance with high cycle life. Initiated basic modeling studies. Delivered battery prototype cells to the USABC for performance evaluation and verification testing in DOE laboratories.	cooperative agreement with the USABC, continue development of the most promising advanced battery technologies--nickel metal hydride and lithium-ion—moving from laboratory cells to 50-volt demonstration modules. Provide results from the tests on prototype modules for industry application in PNGV concept vehicle(s). Refine energy storage/vehicle system requirements, using the test data to validate energy storage models.	cooperative agreement with the USABC, continue the development of high-power nickel metal hydride and lithium-ion technologies. Fabricate a 400-volt high power energy storage nickel metal hydride battery; start life verification testing at a DOE laboratory to characterize the performance against PNGV energy storage requirements for a 400-volt subsystem battery pack. Complete 50-volt high power energy storage lithium-ion module development, initiate performance characterization and life cycle testing at DOE laboratories, and compare results to PNGV technical targets for a 50-volt module. Based on the lithium-ion test results, select one or two of the competing lithium-based technologies for scale-up development to a 400-volt subsystem battery pack for application in the PNGV concept vehicle(s).
	Conducted applied research and developed advanced electrochemical components to address the specific life limiting	Reassess longer term technologies that promise further performance, life, and/or cost benefits to determine their priority for	Initiate a national laboratory effort to focus on the research and development of low cost electrolyte salts and separators for

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	phenomena of high power batteries and ultracapacitors.	application to future energy storage systems. Acquire high voltage test equipment to assess performance characteristics of high power battery systems.	high power batteries, and in situ overcharge protection for lithium-based battery systems.
	Continued the flywheel safety and containment program with the Defense Advanced Research Projects Agency (DARPA), by conducting failure modes and effects analysis, followed by the development of analytical failure prediction models. Proceeded with testing of composite rotor specimens in an effort to gain a better understanding of the physics of rotor failure.	Complete flywheel safety and containment efforts by demonstrating the safe containment of a flywheel during a burst test.	Complete close out of the flywheel program. (USABC, LBNL, LLNL, ORNL, INEEL) (PNGV: $15,000) ($15,000)
	Transitioned nanostructure ultracapacitor technology from high-power propulsion applications to power electronics. Completed testing of bipolar capacitors. (USABC, LBNL, LLNL, INEEL) (PNGV: $8,000) ($8,000)	Complete close-out of the ultra capacitor program. (USABC, LBNL, LLNL, ORNL, INEEL) (PNGV: $9,000) ($9,000)	
	ADVANCED POWER ELECTRONICS: Transitioned the power electronic building	ADVANCED POWER ELECTRONICS: Continue PEBB semiconductor module	ADVANCED POWER ELECTRONICS: Continue the core PEBB program, developing

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	block (PEBB) semiconductor module development activities from series one (PEBB-1) to series two (PEBB-2) designs, incorporating single-side cooled, single and multiple chips. Made samples of these prototypes available to automotive manufacturers for test, evaluation, and determination of conformance to automotive specifications.	technology improvements leading to fabrication of small quantities of PEBB-1 technology that meet automotive functional requirements and are 50% lower in cost, weight, and volume compared to the 1995 baseline. Demonstrate further technology improvements in the laboratory to increase power density and degree of integration. Determine the feasibility of 75% reductions below the 1995 baseline for cost, weight, and volume for the PEBB-2 design. Transition integrated cooling from single-sided to two-sided cooling, and reduce the multi-chip count. Distribute pre-production samples of improved PEBB technology to the automotive industry partners for evaluation.	semiconductor modules for automotive applications. Incorporate technology improvements into limited quantities of prototype PEBB-2 devices aimed at meeting not only the "form" but also the functional specifications developed in conjunction with the automobile manufacturers for traction drive power electronics. Demonstrate improvements by increasing the power density and lowering production cost and assess final results. Initiate demonstration of PEBB-3 modules that have two-sided cooled power electronics integrated with control and communication chips. Evaluate laboratory PEBB-3 modules in advanced vehicle systems. Use the results of the evaluation to measure progress against FY 2000 power electronics technical targets.
	Initiated a power electronics materials needs assessment study.	Complete the power electronics materials needs assessment study.	Based on the results of the materials needs assessment study, develop a research plan for materials technologies to support power electronics and electric machines.

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Systems R&D (Cont'd)	Continued development of nanostructure ultracapacitors transitioned from high power battery development. (GM, Ford, Chrysler, AlliedSignal, Allison, USABC, Navy, Harris Semiconductor, ORNL, SNL, NREL) (PNGV: $3,000) ($3,000)	Develop novel capacitors that permit integration of capacitor functions with power modules. (General Motors, Ford, Chrysler, AlliedSignal, Harris Semiconductor, ORNL, SNL, Navy, TBD) (PNGV: $4,500) ($4,500)	Continue advanced nanostructure and metal oxide chemical vapor deposition (MOCVD) capacitor R&D for power electronics. Integrate nanostructure or MOCVD capacitors into a power electronic module and assess performance against technical targets. (General Motors, Ford, Chrysler, AlliedSignal, Harris, Northrup-Grumman, ORNL, SNL, Navy, DoD, TBD) (PNGV: $5,000) ($5,000)
	$ 53,840	$ 58,200	$ 58,000
Fuel Cell R&D	SYSTEMS DEVELOPMENT: Realigned the fuel cell program into a single effort consisting of projects coordinated through the Fuel Cell Alliance, a joint industry/government alliance that included domestic original equipment manufacturers, fuel cell developers, subsystem and component suppliers, and the fuels industry. The cooperative government/industry management structure directed and guided the	SYSTEMS DEVELOPMENT: Focus systems development activities on validation of fuel cell technologies meeting automotive requirements. Building on the success of the fuel reformer/storage and stack component R&D, fabricate integrated 30-50 kilowatt (kW) fuel cell laboratory systems which operate directly on hydrogen, other alternative fuels and conventional fuels. Demonstrate	SYSTEMS DEVELOPMENT: Integrate fuel cell stack, fuel processor, and balance-of-plant components into a fuel-flexible fuel cell power system that is vehicle ready; capable of operating on natural gas, methanol, ethanol, and gasoline; and demonstrates a system efficiency of 55% at 25% of peak power. Test and evaluate fuel cell power systems under simulated driving cycles for integration into

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)	research and development efforts. Industry collaboratively set the generic fuel cell vehicle system requirements and performance specifications, and jointly established R&D priorities with DOE. The industry alliance focused on the sharing of component development results among the members.	stack efficiencies of 60% and fuel processor efficiencies of 75%. Test and evaluate these propulsion systems under simulated driving cycles.	available test bed vehicles.
	Awarded contracts to fuel cell suppliers and developers for fuel cell propulsion system development. Built a 30 kilowatt (kW) methanol-fueled and a 50 kW hydrogen-fueled proton exchange membrane (PEM) system. Achieved a two-fold increase in power density over 1995 levels in a fuel cell stack, meeting automotive industry mid-term performance and cost goals for light duty vehicles. Achievement of this milestone verified feasibility of a critical component, provided the path to system development, and could lead to fuel cell-powered vehicles which can achieve three times greater fuel economy than today's vehicles with near-zero tailpipe emissions.	Identify critical needs for continued, more focused component development needed to address technical barriers, such as start-up and transient response, power management, thermal management, and reliability. Use propulsion system test results to update system models so that trade-offs among subsystems can be evaluated and component R&D can be prioritized. (International Fuel Cells, Plug Power, ANL) (PNGV: $4,142) ($4,142)	Integrate components to identify vehicle system technical barriers such as cold start-up and transient response, power management, thermal management, durability, and reliability. Use test results to update system models, to facilitate subsystem design analysis, and to prioritize component R&D. (International Fuel Cells, Plug Power, ANL) (PNGV: $7,546) ($7,546)

III. Performance Summary: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)	(GM, Ford, Chrysler/Pentastar, International Fuel Cells, Mechanical Technology, Inc., Energy Partners, Delphi, AlliedSignal, and others) (PNGV: $11,760) ($11,760)		
	COMPONENT R&D: Continued work on supporting ongoing PEM technology development efforts and identifying promising new concepts, with oversight by the Fuel Cell Alliance. Developed bipolar plates that are highly conductive and corrosion resistant at a small scale (50 sq. cm), and membrane electrode assemblies with improved tolerance to carbon monoxide (10 parts per million). Developed and tested high efficiency compressors and expanders for fuel cell applications.	COMPONENT R&D: Fuel cell propulsion system components must meet technical challenges such as size and weight reduction, manufacturing cost reduction, quick start-up and transient response, and durability. Focus development on low cost, high performance components for proton exchange membrane (PEM) fuel cells. Produce improved fuel cell catalysts which are able to tolerate 50 parts per million (ppm) carbon monoxide from the hydrogen-rich fuel processing stream without performance degradation. Develop membrane-electrode assemblies employing low platinum loadings or non-noble catalyst formulations for reformatted systems. Investigate alternative bipolar plates that are low cost and lightweight, such as conductive plastics separator plates.	COMPONENT R&D: Continue to focus R&D activities on low cost, high performance components for proton exchange membrane fuel cells. Develop improved fuel cell catalysts which are able to tolerate 100 ppm carbon monoxide from the hydrogen-rich fuel processing stream without performance degradation. Establish stability and durability of catalysts through long-term testing. Build and test fuel cell stack systems operating on reformated, which incorporates new, low cost, lightweight bipolar plates and high carbon monoxide-tolerant catalysts. Complete development of advanced compressors and expanders demonstrating 80 and 90% efficiency, respectively.

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)		Investigate low cost, high volume manufacturing processes to produce advanced bipolar plates, membrane electrode assemblies, and other fuel cell components having reproducible performance and leading to a fuel cell stack having a power density of 850 watts/liter (W/l).	Increase emphasis on development of low cost, high volume manufacturing processes of fuel cell components leading to a fuel cell stack system (including air, heat and water management devices) having an automotive power density of 350 W/l.
	Continued direct methanol fuel cell development, with the demonstration of 1,000 hours of stable performance on a single test cell.	Produce a new methanol impermeable membrane to facilitate the development of direct methanol fuel cells, eliminating the need for a reformer.	If previous R&D activities are successful, begin scale-up of direct methanol fuel cell to 5 kilowatt (kW) level.
	(ANL, LANL, Energy Partners, Texas A&M, International Fuel Cells, AlliedSignal, Vairex) (PNGV: $4,500) ($4,500)	Conduct independent testing and evaluation of new components and systems, to identify and assess promising new technologies and/or technical approaches.	Continue independent testing and evaluation of new components and stack systems.
		Coordinate with the other fuel cell activities to facilitate the integration of advanced components into the total system.	Coordinate with systems development efforts to facilitate integration of advanced components into the total system.
		(AlliedSignal, Foster-Miller, Energy Partners, Spectracorp, Electrochem, IGT, 3M, A.D. Little, Vairex, Meruit, LANL,	(TBD, ANL, LANL) (PNGV: $18,100) ($18,100)

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)		ANL, LBNL, NREL) (PNGV: $11,078) ($11,078)	
	REFORMER AND STORAGE R&D: Continued to build on the R&D breakthroughs and lessons learned from the 50 kW fuel flexible reformer. Focused the fuel flexible reformer program on unique issues associated with gasoline, and demonstrated technical feasibility of producing electricity from gasoline.	REFORMER AND STORAGE R&D: In cooperation with the DOE Hydrogen Program, focus R&D on development and testing of low cost, lightweight hydrogen storage systems for on-board vehicle use. Due to the lack of a hydrogen infrastructure, develop hydrogen producing fuel processors. Building on previous R&D breakthroughs, develop a 50 kW fuel-flexible processor capable of rapid start-up (less than 3 minutes) and fast response processing of natural gas, methanol, ethanol, and gasoline. This fully integrated system will include all components (reactors, heat exchangers, fuel purification system, controls and sensors) and be sufficiently compact and lightweight for test-bed vehicle installation.	FUEL PROCESSOR AND STORAGE R&D: Complete fabrication and safety testing of hydrogen storage tanks, for on-board vehicle use, having an available energy density of 700 watt-hours per liter (Wh/l). Complete development of a compact, lightweight, 50 kW fuel-flexible fuel processor capable of rapid start-up (less than 3 minutes), and fast response processing of natural gas, methanol, ethanol and gasoline. This fuel processing system will be fully automated and ready for integration with the fuel cell stack system. Address development of a low pressure, low temperature fuel-flexible fuel processor with automotive controls, eliminating the need for a compressor when integrated with a low pressure fuel cell, while improving start-up time and overall system efficiency. Build advanced CO clean-up prototypes to lower CO to less

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)	Worked on developing improved fuel processing catalysts and carbon monoxide (CO) clean-up catalysts. Validated other innovative concepts (e.g., CO adsorption) to increase energy efficiency and fuel stream purity.	Address remaining key barriers: removal of carbon monoxide (CO) from the fuel stream (critical because even small levels of CO (50 ppm) can poison the fuel cell stack catalyst); system thermal integration; and cost reduction. Evaluate preferential oxidation, hydrogen filters, and adsorption/desorption techniques to lower CO levels to less than 10 ppm.	than 10 ppm. Down select from advanced preferential oxidizers, hydrogen filters, and adsorption/desorption devices, and integrate into fuel processor.
		Using microtechnology, develop compact, efficient heat exchangers and fuel pre-heaters to provide integrated thermal management, maximizing system efficiency and power density.	Optimize and scale up compact, efficient heat exchangers and fuel pre-heaters which utilize microtechnology.
	Made awards to fuel processing developers and national laboratories. This activity will lead to a 50 kW compact, lightweight, low cost fuel processor system which meets automotive requirements for steady state operations, and which can process natural gas, ethanol, methanol and gasoline. (ANL, LANL, A.D. Little, Hydrogen Burner) (PNGV:	Coordinate with system development efforts to facilitate integration of the fuel processor into the total system. Acquire fuel cell test stand apparatus and a gas stream analyzer. (LANL, ANL, PNNL, LBNL, Hydrogen Burner, A.D. Little, Thiokol, Thermo Power) (PNGV: $8,340) ($8,340)	Coordinate with systems development efforts to facilitate integration of the fuel processor into the total system. (Hydrogen Burner, A.D. Little, Thiokol, Thermo Power, ANL, LANL) (PNGV: $19,000) ($19,000)

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Fuel Cell R&D (Cont'd)	$4,500) ($4,500)		
	$ 20,760	$ 23,560	$ 44,646
Advanced Combustion Engine R&D	Increased support for advanced automotive piston engine technologies which have the potential for achieving a threefold improvement in vehicle fuel efficiency, as well as nearer term conventional vehicle improvements.	Continue support for advanced automotive piston engine technologies required to achieve a threefold improvement in vehicle fuel efficiency as well as nearer term conventional vehicle improvements.	Conduct R&D which will enable fuel efficient compression ignition direct injection (CIDI) engines to meet stringent Federal and State emission requirements.
	Combustion: Continued optical access measurement and numerical modeling of fluid flow and chemistry, analysis of fuel-air mixture formation and combustion in production engines. Upgraded models to include lean-burn fuel injection simulation and validate against experimental data.	Combustion: Continue optical access measurement and numerical modeling of fluid flow and chemistry, analysis of fuel-air mixture formation and combustion in production engines. Continue refinement of models which include lean-burn fuel injection simulation. Validate against experimental data.	Combustion: Continue optical access, single-cylinder combustion research to directly measure injection spray patterns and combustion processes using laser visualization. Characterize inlet and in-cylinder flows and effects of wall heat transfer and exhaust gas recirculation. Correlate optical measurements with numerical models to validate and refine model for optimization of fuel injection, sensor, and exhaust gas recirculation (EGR) systems.
	Emission Controls: Initiated development of a diagnostic tool to identify sources of unburned	Emission Controls: Continue development of diagnostic tool to identify sources of unburned	Emission Controls: Develop cost effective ($5/kilowatt (kW) versus current $15/kW) control and

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Advanced Combustion Engine R&D (Cont'd)	hydrocarbons in engine exhaust.	hydrocarbons in engine exhaust. Continue development of lean-NOx catalyst and other exhaust after treatments.	aftertreatment system to reduce gaseous and particulate emissions. Scale up NOx catalyst and plasma-assisted catalyst systems to 50 kW-engine capacity and test performance/durability (goal greater than 3,500 hours). Continue non-combustible gas sensor development for closed-loop control. Initiate development of accurate, low density particulate sensors and develop initial control system design.
	Engine Integration: Continued development of fuel injection, alternative fuel capability and other enabling technology elements. Conducted projects in partnership with DOE laboratories, universities, industry. Coordinated with the Advanced Heavy Vehicle Technologies program.	Engine Integration: Continue development of CIDI technology, fuel injection, alternative fuel capability and other enabling technology elements. Continue projects in partnership with DOE laboratories, universities, industry. Coordinate with the Advanced Heavy Vehicle Technologies program.	Engine Integration: Benchmark prototype components and control strategies, and compare to state-of-the-art, multi-cylinder engines. Continue projects in partnership with DOE laboratories, universities, and industry. Coordinate with the Advanced Heavy Vehicle Technologies program.
	(ANL, ORNL, PNNL, INEEL, SNL, Ford, GM, Chrysler, Princeton, Penn State University, Wayne State University, University of Wisconsin, University of Illinois, MIT, Drexel, Florida, A&M) (PNGV:	(ANL, ORNL, PNNL, SNL, Ford, GM, Chrysler, Princeton, Penn State University, Wayne State University, University of Wisconsin, University of Illinois, MIT, Drexel, Florida A&M, TBD) (PNGV: $7,600) ($7,600)	(ANL, ORNL, PNNL, SNL, Ford, GM, Chrysler, Wayne State University, University of Wisconsin, TBD) (PNGV: $18,000) ($18,000)

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Advanced Combustion Engine R&D (Cont'd)	$7,460) ($7,460) $ 7,460	$ 7,600	$ 18,000
Cooperative Automotive Research for Advanced Technologies	No Activities. ($0)	No Activities. ($0)	Under the Partnership for a New Generation of Vehicles, support a Cooperative Automotive Research for Advanced Technologies (CARAT) program which provides an opportunity for small businesses and universities to help accelerate progress on inventions needed for advanced vehicle technologies. Issue a solicitation inviting proposals that describe how specific technical targets might be met in the areas of, but not limited to: fuel cells, compression ignition direct injection engines, spark ignition engines, alternative fuels, energy storage, and lightweight materials. Award multiple, cost-shared cooperative agreements to conduct research and development under a three-stage program, from bench modeling and preliminary development plans in Phase 1 through validation of production feasibility in Phase 3. (PNGV:

III. <u>Performance Summary</u>: ADVANCED AUTOMOTIVE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Cooperative Automotive Research for Advanced Technologies (Cont'd)	$ 0	$ 0	$6,000) ($6,000) $ 6,000
Advanced Automotive Technologies Total	$ 102,717	$ 113,296	$ 144,646

TRANSPORTATION TECHNOLOGIES

TRANSPORTATION SECTOR
(dollars in thousands)

ADVANCED HEAVY VEHICLE TECHNOLOGIES

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission

Since the 1973 Arab oil embargo, data from the Energy Information Agency indicates that essentially all of the increase in highway fuel consumption has been due to trucks. In 1996, trucks consumed as much fuel as automobiles due to the continued growth of freight transport provided by heavy trucks and the explosive growth in the popularity of relatively low miles per gallon (mpg) light trucks such as pickups, vans, and sport utility vehicles used for personal transport. The gross domestic product, and hence economic activity, depends on the movement of goods. Truck energy use is less discretionary; trucks are the mainstay for trade/commerce and economic growth and, thus, critical to the economy.

The goal of Advanced Heavy Vehicle Technologies R&D is to develop, by 2004, the enabling technologies needed to achieve fuel-flexibility, ultra-low emissions, and 10 miles per gallon (mpg) fuel economy in Class 7-8 trucks (currently the most efficient new trucks get 7 mpg, with a fleet average of 5.3 mpg), while simultaneously devolving these technologies to pickups and sport utility vehicles (Class 1-2 trucks). These technologies will enable pickup trucks to achieve at least a 35 percent efficiency improvement relative to current gasoline-fueled trucks. The strategy is to focus R&D efforts primarily on improving the efficiency, emissions characteristics, and alternative fuel capability of the diesel cycle engine. This strategy supports the DOE strategic goals of enhanced energy productivity (Goal 1), reduced vulnerability (Goal 2), reduced environmental impacts (Goal 3), and economic/regional equity (Goal 4), through the development of energy efficient/alternative fuel capable clean diesel engine technologies.

The diesel has the highest efficiency of the commercial engines used in highway vehicles today (44 percent efficient vs. 24 percent for production gasoline engines), and can be made even more efficient (at least 55 percent) with advanced technologies. The diesel engine is the engine of choice for heavy duty trucks used for commercial transport because it offers power, efficiency, reliability, and durability. It runs on alternative fuels, e.g., natural gas, dimethyl ether, ethanol, methanol, biodiesel, and can be made fuel flexible, i.e., use more than one kind of liquid fuel in the same engine. With successful research and development, diesel engine exhaust can be cleaned up to ultra low emissions through a combination of in-cylinder combustion control, exhaust aftertreatment, and fuel formulation. Because diesel engine manufacturers have the production and nationwide field service infrastructure in place, this technology constitutes an attractive potential technology for efficiency improvements by replacing gasoline engines with "clean diesels" in the fastest growing market segment of pickup trucks and sport utility vehicles.

I. Mission Supporting Goals and Objectives: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Continual improvement of diesel engine efficiency and fuel flexibility is a real, achievable strategy for maintaining the energy and economic security of the trucking industry. Further reducing truck energy use is perhaps most readily achievable through devolution of energy efficient, fuel-flexible, ultra low emissions heavy duty diesel engine technologies through all truck classes. For instance, annual sales of Class 1-2 trucks, essentially all of which use less efficient gasoline-fueled engines, have increased dramatically in the past 12 years, from approximately 3 million vehicles in 1983 to over 6 million vehicles in 1995 (from 25 to 42 percent of the foreign and domestic highway vehicle sales in the U.S.). The vehicle production industry is shifting substantial manufacturing emphasis to light trucks in response to the growth in demand for pickups, sport utility vehicles, and vans. The diesel engine can provide power (especially needed for four-wheel drive, hauling, and towing--popular features of pickups and sport utility vehicles) and ruggedness, in addition to higher energy efficiency. Emissions control technologies to meet increasingly more stringent environmental standards are the key enablers for greater utilization of the inherently higher efficiency diesel engine. This is the critical requirement for market entry if potential energy savings are to be realized. Advanced Heavy Vehicle Technologies program activities will continue to focus on the diesel engine in both heavy vehicle systems R&D and heavy vehicle alternative fuels R&D.

Heavy Vehicle Systems R&D activities are primarily focused on two areas: a) high efficiency engine R&D, with a specific goal to achieve 55 percent efficient diesel engines for heavy duty trucks, and an adaption of this diesel engine technology for sports utility vehicles and light trucks; and b) heavy vehicle systems technologies R&D focused on the transfer of an electric and hybrid electric vehicle program from the Defense Advanced Research Projects Agency (DARPA) to a joint DOE/Department of Transportation program, with the intent of applying electric propulsion technologies to medium and heavy trucks and buses. A second part of the systems program will continue the evaluation of the reduction of parasitic energy losses from aerodynamics, rolling resistance, and accessories in conventional on-highway large trucks.

The high efficiency light truck engine R&D program is integrated with the Partnership for a New Generation of Vehicles (PNGV) compression ignition direct injection (CIDI) diesel engine technology program. Critical enabling technology will be developed cooperatively between the U.S. diesel engine manufacturers and the U.S. automakers. These engine concepts integrate major design advances such as higher peak cylinder and fuel injection pressures, increased sophistication in microprocessor control, improved turbocharger efficiency, and the introduction of turbo compounding, in addition to a substantial effort in cost and size reduction. Diesel engine performance will be optimized, while reducing emissions to or below EPA standards, by simultaneously addressing in-cylinder combustion control, exhaust aftertreatment technologies, and fuel formulation strategies. Modeling and validation of engine combustion will continue to enable more definitive understanding of the chemical species formed in the combustion process.

Electric and hybrid electric technologies developed with DARPA funding through the Advanced Transportation Technology Consortia (ATTC) have matured to a level that requires a focus on specific applications to complete the development cycle. Many urban service vehicles, such as delivery trucks and buses, can utilize electric propulsion to achieve much higher fuel efficiency and substantially reduced emissions of criteria pollutants and greenhouse gases. These vehicles are typically operated and managed as part of fleets, both government and private. Fleet applications with the highest potential for energy and carbon savings, as well as economic success, will be used to guide the next phase of development under DOE and DOT. Test vehicles are expected to be completed and placed in the fleets for evaluation as early as 2000. The diversity and typical low manufacturing volume of service type vehicles will require

that several different applications be identified to achieve a large impact. This is compatible with the structure of the ATTC, allowing each region to independently bring value to the program.

Heavy Vehicle Alternative Fuels R&D activities focus on developing advanced enabling technologies (e.g., fuel sensors, electronic valve timing coupled with closed-loop feedback electronic control systems, lubrication requirements, etc.) necessary for the diesel engine to operate on natural gas and be fuel flexible, and to operate optimally on other alternative fuels and blends (e.g., natural gas liquids and derivatives like dimethyl ether, and renewable fuels such as ethanol derived compression ignitable fuels (e.g., diethyl ether) and biodiesel). A complementary combustion research activity focuses on alternative fuels appropriate for heavy vehicle use. Research tools developed for diesel fuel combustion R&D are applied in the investigation of the energy conversion efficiency and emissions from alternative fuels. Fuel formulation strategies focus on obtaining minimum emissions.

Responding to customer input, the Heavy Vehicle Technologies program embarked in FY 1997 on a major effort to increase the efficiency of natural gas engines from their current 37 percent level to be more nearly coincident with the current 44 percent efficiency of heavy duty diesel engines. These efforts will be maintained in FY 1999 and will contribute significantly to the economical transition to and operation of heavy duty Class 7-8 trucks on liquefied natural gas (LNG). Also in FY 1999 another research emphasis will be maintained to enhance the on-board storage of natural gas to enable the transition to and operation of Class 3-6 (local delivery) trucks on compressed natural gas (CNG). Trucks operating on such a clean fuel as natural gas in downtown non-attainment areas will make a substantial contribution to reducing the vehicular pollution burden in these areas.

For FY 1999, program integration and collaborative research leveraging efforts begun in FY 1997 with the DOE Office of Energy Research (ER) and the Office of Fossil Energy (FE) will be expanded and solidified. The Heavy Vehicle Technologies program was awarded support by ER for two collaborative pilot projects focused on diesel engine emissions control research. Dubbed "DOE 2000," the ER initiative is funding the development and emplacement of the high speed information network to enable geographically distributed researchers to collaborate in the areas of diesel combustion and catalytic aftertreatment of diesel exhaust. The Heavy Vehicle Technologies program is supporting both scientific combustion studies and extensive diesel engine testing of compression ignitable clean diesel fuels coming from the research efforts of FE's Advanced Fuels Conversion and Liquefaction Programs. The Heavy Vehicle Technologies Program is supporting research at the High Temperature Materials Laboratory (HTML) to characterize catalysts needed by these programs to advance these fuels processing technologies to commercial reality. Characterization of carbon produced materials from coal will also be maintained in support of FE.

The Heavy Vehicle Systems R&D program efforts in the high efficiency large diesel engine projects will continue to be coordinated with the Heavy Vehicle Alternative Fuels R&D program, to accelerate the usage of alternative fuels in the largest truck classes. The track record of the high efficiency engine program for improving the state of the art is reflected in the improved efficiency of current production engines--a success story brought about through industry/government cooperation. The advancements in alternative fuel enabling technologies developed under the Heavy Vehicle Alternative Fuels R&D program have proven that fuels, such as natural gas, its derivatives and biodiesel are technically viable and have major benefits. The combination of the two programs will encourage the U.S. diesel industry to offer efficient natural gas and flexible fuel technologies in mainstream production engines.

I. **Mission Supporting Goals and Objectives**: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Program planning for the Advanced Heavy Vehicle Technologies program has been conducted in collaboration with stakeholders in the trucking industry diesel engine manufacturers, natural gas industry, automakers' truck divisions and fuels producers. The first of several industry/government workshops provided customer input from heavy duty diesel engine manufacturers, truck manufacturers and their association, and truck users. The workshop itself was co-sponsored by the Truck and Bus Division of the Society for Automotive Engineers. Other workshops have addressed other areas of opportunity for technical collaboration to achieve increased energy efficiency in the heavy vehicle portion of the transportation sector.

I. B. Program Benefits

Metric*	2000	2010	2020
Primary Energy Displaced (Quads)	0.01	0.32	0.61
Primary Oil Displaced (million barrels per day)	.005	0.15	0.29
Energy Cost Savings ($ billion)	.07	3.00	5.46
Carbon Reductions (million metric tons)	.18	5.89	11.34

*Includes benefits for heavy vehicle propulsion materials.

I. C. Performance Measures

Heavy Vehicle Systems R&D:
Strategy/Goal: Focus on the diesel engine. By 2004, in partnership with the diesel engine manufacturers, truck manufacturers, and their suppliers, develop technologies for enabling fuel flexibility and heavy duty truck fuel economy to increase to 10 mpg from the current average of 7 mpg, with simultaneous devolution of these technologies to the mid-range (Class 3-6) and Class 1-2 trucks, achieving at least 35 percent efficiency improvement over gasoline-fueled trucks.

FY 1997 Accomplishments

-- Demonstrated multi-cylinder engine concepts with teams led by engine manufacturers that achieve 50 percent efficiency while reducing emissions to 3.0 grams/brake horsepower-hour (g/bhp-hr) for nitrogen oxides ($NO_{x)}$ and 0.5 g/bhp-hr for particulates.

-- Achieved 60 percent NO_x and particulate reduction in diesel engine exhaust by using a non-thermal plasma device, with a 5 percent fuel penalty, in a collaborative program with California's South Coast Air Quality Management District.

-- Undertook testing of microwave regenerated particulate trap with 90 percent trapping efficiency of even small particulates (2.5 microns in diameter).

I. Mission Supporting Goals and Objectives: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

FY 1998 Planned Accomplishments

-- Conduct laboratory experiments to achieve a 69 percent efficiency in a turbocharger for diesel engines; integrate with multi-cylinder engine design.

-- Achieve a simultaneous 80 percent reduction in diesel engine NO_x and particulate emissions using a non-thermal plasma device, with less than 5 percent fuel penalty.

-- Complete initial performance specifications of critical enabling technologies, as well as cost goals, for the high efficiency diesel engine to replace the lower efficiency spark ignition gasoline engine for light truck applications (sport utility vehicles, vans, pickup trucks).

-- Undertake design and cycle analysis of the diesel engine concept for light trucks. Initiate single-cylinder engine fabrication.

-- Conduct a series of experiments to better understand the diesel engine combustion process. Investigate in-cylinder strategies that will yield improvements in engine efficiency. Determine the mechanisms which lead to the formation of NO_x and particulate emissions.

-- Establish joint EE/ER "collaboratory" R&D efforts in combustion, catalysis, and fuel chemistry to optimize the energy conversion efficiency of the diesel engine.

FY 1999 Planned Accomplishments

-- Demonstrate advanced concepts that lead to at least 40-45 percent thermal efficiency in multi-cylinder diesel engines for light trucks, while substantially reducing NO_x and particulates.

-- Complete development of a prototype non-thermal plasma device for simultaneous 80 percent reduction of NO_x and particulates. Initiate field test of prototype.

-- Within the EE/ER "collaboratory" efforts, complete establishment of a combustion component team of researchers needed to develop the knowledge base to achieve near-zero emission levels from a high efficiency diesel engine.

-- Validate with experimental data that the combustion computer model accurately simulates fuel injection, combustion, and emissions formation processes.

I. Mission Supporting Goals and Objectives: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

FY 2000-FY 2004 Planned Accomplishments

-- Complete the development of enabling technologies for clean diesel engines to be used in light trucks.

-- Make available to the industry a predictive computer modeling tool that will drastically shorten the process of designing cleaner diesel engines.

Heavy Vehicle Alternative Fuels R&D:

Strategy/Goal: By 2004, in partnership with the diesel engine manufacturers, alternative fuel developers and producers, truck manufacturers, and their suppliers, develop the technologies for enabling clean and efficient natural gas utilization and liquid fuel flexibility using non-petroleum fuels in diesel engines, while maintaining the efficiency and emissions at levels comparable to, or better than, those achievable with petroleum-based diesel fuel.

FY 1997 Accomplishments

-- Achieved reliable compression ignition (i.e., without glow plugs) in a heavy duty, high efficiency, direct injected natural gas diesel engine.

-- Continued on-road development of liquefied natural gas (LNG) engine/vehicle systems utilizing the West Virginia University (WVU) chassis dynamometer for evaluation.

-- Completed evaluation of heavy vehicle contributions to urban airshed inventories.

-- Designed and burst tested, at 8,800 pounds/square inch, a carbon composite conformable shaped compressed natural gas tank with 40 percent more fuel volume than currently used cylindrical tanks.

-- Began development of next generation natural gas engine aimed at solving the part load and lean limit operation efficiency and emissions problems of current technology.

FY 1998 Planned Accomplishments

-- Conduct on-road testing of heavy duty engines using direct injected natural gas, pilot ignition natural gas, and dimethyl ether.

-- Continue development of next generation natural gas engine with the goal of achieving 55 percent efficiency.

-- Complete development of technical methods for assessing impacts of heavy vehicles on air quality.

I. Mission Supporting Goals and Objectives: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

-- Perform proof-of-concept burst tests on medium pressure liquefied natural gas conformable tanks and complete certification tests (based on the Department of Transportation's (DOT's) certification criteria) on high pressure compressed natural gas conformable tanks having cost and weight advantages over currently used tanks.

-- Evaluate the combustion initiation and propagation of low-cetane number fuels.

-- Initiate an EE/ER collaboratory on non-thermal/plasma assisted catalysts.

-- Undertake design of full-up heavy duty diesel engine concepts (e.g., variable valve timing technology) for liquid fuel-flexible operation (e.g., ethanol, methanol, dimethyl ether, biodiesel).

-- Evaluate the direct fuel injection characteristics of alternative fuels and their effects on combustion and emissions.

FY 1999 Planned Accomplishments

-- Complete build of single-cylinder proof-of-concept fuel-flexible low emission 55 percent efficient engine.

-- Complete input database files for air quality modeling of heavy vehicles using alternative fuels in urban centers.

-- Test proof-of-concept next generation natural gas engines to demonstrate optimum efficiency level.

-- Develop advanced liquefied natural gas storage systems for heavy vehicles that reduce life-cycle costs by 25 percent, achieve a ten-fold reduction in fuel boil-off rate, and conserve 5 percent of the fuel value.

-- Continue evaluation of direct fuel injection characteristics of alternative fuels and their effects on combustion and emissions.

-- Investigate the combustion characteristics of alternative fuels in an optically accessible diesel engine.

FY 2000 - FY 2004 Planned Accomplishments

-- Publish a comprehensive report on the emissions, performance, and durability of alternative fuels, including natural gas, natural gas derivatives, alcohol, and biomass derived fuels in Class 3-8 trucks.

-- Devolve alternative fuel technologies developed for Class 3-8 trucks into light truck/sport utility vehicles.

II. A. Funding Table: ADVANCED HEAVY VEHICLE TECHNOLOGIES

Program Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Heavy Vehicle Systems R&D	$ 6,970	$ 12,900	$ 33,200	$ 20,300	157%
Heavy Vehicle Alternative Fuels R&D	12,159	12,700	11,000	-1,700	-13%
Total, Advanced Heavy Vehicle Technologies	$ 19,129	$ 25,600	$ 44,200	$ 18,600	73%

II. B. Laboratory and Facility Funding Table: ADVANCED HEAVY VEHICLE TECHNOLOGIES

Argonne National Lab (East)	$ 609	$ 820	$ 1,500	$ 680	83%
Brookhaven National Lab	1,400	2,000	3,000	1,000	50%
Idaho National Engineering and Environmental Lab.	100	0	0	0	0%
Los Alamos National Laboratory	45	165	650	485	294%
National Renewable Energy Lab	5,082	6,070	12,000	5,930	98%
Oak Ridge National Lab	2,780	2,840	4,000	1,160	41%
Sandia National Laboratories	1,575	825	1,500	675	82%
All Other	7,538	12,880	21,550	8,670	67%
Total, Advanced Heavy Vehicle Technologies	$ 19,129	$ 25,600	$ 44,200	$ 18,600	73%

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Systems R&D	HIGH EFFICIENCY ENGINE R&D: In order to enable major fuel use reductions in essential truck transportation, while also meeting more stringent emission standards, continued research and development of broadly applicable low emission (LE)-55 engine concepts with teams led by engine manufacturers. Tested LE-55 concepts in multi-cylinder engine configurations. Concepts included components and designs to increase engine mean effective pressure, reduce friction, and recover exhaust energy. Developed and integrated advanced control systems, 70% efficient turbochargers, ring/piston design, sensors, lubricants, turbo compounding, engine thermal management, and application of advanced materials. Continued evaluation and development of innovative exhaust energy recovery technologies. Continued investigating efficiency and emissions at ultra-high combustion pressures. Continued research and development (on heavy vehicles)	HIGH EFFICIENCY ENGINE R&D: Implement initial stages of a planned program to devolve the technologies under development in the LE-55 heavy duty engine program to diesel engines of the size and duty cycle appropriate for light trucks (100-275 horsepower). Complete the first phase of a 50% cost-shared program that will define the critical path to achieving a 35% fuel efficiency improvement in light trucks. The second phase will include development of critical technologies to increase engine mean effective pressure, reduce friction, and improve exhaust energy utilization. Identify technologies needed to meet the additional challenge of meeting more stringent performance and emissions standards for vehicles under 8,500 pounds gross vehicle weight rating.	HIGH EFFICIENCY ENGINE R&D: Continue program of diesel engine R&D for light trucks, pickups, vans, and sport utility vehicles. Using competitive industry teams led by domestic diesel engine manufacturers and U.S. auto manufacturers, the program goal is to achieve at least a 35% fuel efficiency improvement in light trucks, with very low emissions. Maintain at least a 50% cost share on the part of industry. Include technologies that will enable the high efficiency diesel engine to meet market and regulatory demands for performance, noise, cost, and emissions. Specific technologies may include: components to increase engine mean effective pressure, reduce friction, and improve exhaust energy utilization; advanced control systems; fuel injection equipment; high efficiency turbochargers; ring/piston designs; sensors; lubricants; engine thermal management; and utilization of advanced materials (including lightweight components).

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Systems R&D (Cont'd)	of the most promising emission reduction technologies. Carried out scale-up and prototype testing of catalytic exhaust converters for nitrogen oxides (NOx), advanced particulate trap concepts with microwave regeneration, and fuel modifications. Accelerated full system tests, integrating necessary sensors for control, and hydrocarbon injection systems for NOx and particulate matter reduction. Continued projects to reduce engine emissions through combustion optimization using modeling and engine validation. Developed integrated engine/ aftertreatment systems targeted toward Environmental Protection Agency (EPA)/California Air Resources Board (CARB) 2004 emissions standards. Continued iterative chemical reformulation of the Texaco NOx reduction fuel additive and its evaluation in an expanded set of engines. Coordinated with advanced automotive piston engine R&D activities.	Support an industry-wide cooperative effort between the major U.S. vehicle manufacturers and the U.S. diesel engine manufacturers. In partnership, investigate efficiency and emissions at ultra-high combustion pressures, using facilities at the national laboratories and universities. Perform fundamental combustion research by utilizing laser diagnostic and computer modeling techniques. Investigate the formation of oxides of nitrogen and particulates in the combustion chamber of diesel and alternative fuel engines, and how they are affected by such parameters as fuel injection, combustion chamber geometry, temperature and density.	Continue to support base technology research and development for the diesel engine with the U.S. diesel engine manufacturers, the U.S. vehicle manufacturers, the U.S. EPA, and the U.S. Army. Focus base technology R&D on combustion optimization and exhaust aftertreatment research. Perform combustion optimization research in an optically accessible diesel engine and an ultra high pressure combustion vessel, using laser diagnostics and high speed photography. Use experimental data in the development of computer models to simulate the diesel combustion process. The Office of Energy Research will enhance this research effort by funding the DOE 2000 Diesel Combustion Collaboratory Pilot Project. Focus exhaust aftertreatment projects on the treatment of nitrogen oxides and particulates that remain in the exhaust stream after the in-cylinder combustion event. In cooperation with the Advanced Automotive Technologies program, explore

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Systems R&D (Cont'd)			several options, including a catalyst, non-thermal plasma, and combinations of the two together with particulate and NOx traps.
	(ORNL, SNL, NREL, Caterpillar, Cummins, DDC, HiZ, Texaco, Univ. of Wisconsin) ($6,970)	(ORNL, SNL, Univ. of Wisconsin, LANL, diesel industry, Univ. of Illinois, other universities, Texaco, NOxTech) ($11,200)	(SNL, LANL, ORNL, diesel industry, auto industry, Univ. of Wisconsin, other universities) ($22,200)
	HEAVY VEHICLE SYSTEMS TECHNOLOGIES: Evaluated heavy vehicle systems to identify opportunities for improvement of vehicle efficiency in the areas of aerodynamics, rolling resistance, and accessory systems (e.g., air conditioning loads and braking systems).	HEAVY VEHICLE SYSTEMS TECHNOLOGIES: Delineate potential cost-effective methodologies to reduce parasitic energy losses endemic in the operation of heavy vehicles. Further evaluate the effects of proposed energy saving approaches in the areas of aerodynamics, rolling resistance, and auxiliary systems.	HEAVY VEHICLE SYSTEMS TECHNOLOGIES: Parasitic energy consumption arising from aerodynamic drag, rolling resistance, and auxiliary on-board systems accounts for 52%, 28%, and 20%, respectively, of the non-engine energy losses in heavy vehicle operations. Develop, with trucking industry participation, comprehensive multi-year program plans (MYPPs) that will address potentially effective methodologies to reduce parasitic energy losses, and will provide a prioritized, focused R&D agenda to develop cost effective, energy efficient heavy vehicle systems designs. Total near-term increases in energy efficiency of heavy vehicles is estimated to be
	Evaluated enhanced sensoring requirements, weight savings, safety needs and operational characteristics of advanced fuel handling and fuel storage systems for heavy commercial vehicles. Evaluated prototype/advanced/emerging technologies for transit, intercity,	Employing a fully integrated systems approach, further develop sensoring, weight reduction, safety and operational characteristics of fuel systems for heavy commercial and multi-purpose vehicles. Apply systems integration analysis to increase the energy efficiency, safety, and cost effectiveness of	

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Systems R&D (Cont'd)	and school bus vehicles. (In-house) ($0)	transit, intercity, and school bus vehicles. (ANL, MIT, WVU, AAR, TBD) ($1,700)	in excess of 10% across the fleet, with concomitant reduction in greenhouse gases and other emissions of concern. Assemble teams with the appropriate skill mixes to expand research and developmental efforts in the three top areas identified in the MYPPs. Assess this fully integrated systems engineering approach, developed for the analysis and amelioration of parasitic energy losses in heavy duty trucks, for broader application to transit, intercity, and school buses. (ANL, MIT, WVU, AAR, TBD) ($1,000)
	No Activities. ($0)	No Activities. ($0)	ADVANCED TRANSPORTATION TECHNOLOGY CONSORTIA: Transition the Advanced Transportation Technology Consortia (ATTC) program from the Defense Advanced Research Projects Agency (DARPA) to an equally funded, 50% industry cost shared, Department of Energy/Department of Transportation program focusing on truck applications. Through this combined program, complete the development of electric and

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Systems R&D (Cont'd)			hybrid propulsion technologies, directed at civilian applications such as trucks and buses, that was initiated by DARPA through seven regional consortia consisting of small and large businesses and State and local governments. Dedicated to the challenge of bringing electric-based propulsion, and other high efficiency technologies, to commercial and public transportation, the Consortia offer a means to team local manufacturers with vehicle users, such as transit districts, to seed a demand for the advanced technology in a highly segmented transportation sector. Focusing the program on applications identified in this manner will result in several parallel regional projects. This effort is closely integrated and coordinated with the Advanced Automotive Technologies program. ($10,000)
	$ 6,970	$ 12,900	$ 33,200

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Alternative Fuels R&D	Enabling Technology: Completed evaluation and demonstration of compressed natural gas (CNG) storage system in three prototype vehicles. Initiated development of three medium duty (urban delivery trucks, for example) engines for alternative fuel operation. Initiated fundamental combustion studies to explore the mechanisms of nitrogen oxides (NOx) formation in biodiesel and natural gas combustion. Demonstrated the operation of a heavy duty diesel engine using direct injected natural gas. Demonstrated the operation of a heavy duty diesel engine on dimethyl ether (DME). Developed liquefied natural gas (LNG) storage systems to be compatible with advanced engines. Applied modeling results to the database for environmental impacts of alternative fuels in non-attainment areas. Completed quantitative measurements of volatile organic compounds emitted from advanced alternative fueled vehicles. Completed cost-shared program with the Coordinating Research Council to co-fund	Enabling Technology: Continue fundamental combustion studies and expand the scope to include diesel/alternative fuel blends. Conduct combustion research on alternative fuel blends, including DME and Fisher Tropsch diesel from natural gas. Utilize the capabilities of the DOE 2000 supercomputer, developed by Defense Programs, to model and develop the relationships among fuel formulation, in-cylinder combustion, and exhaust after treatment. Design and begin development of a three-way catalyst for heavy duty natural gas engines. Evaluate advanced NOx control technologies to control emissions of diesel/alternative fuel blends. Identify heavy vehicle emissions inventory and composition of heavy vehicle volatile organic compound (VOC) emissions from alternative and conventional diesel fuels. Identify and conduct additional cost-shared research in cooperation with the Coordinating Research Council, to extend the previous light duty vehicle emissions impacts to heavy vehicles. Conduct preliminary	Enabling Technology: With industrial partners, continue fundamental combustion studies on alternative fuel/diesel fuel blends, to determine their effects on NOx and particulate emissions formation in a diesel engine. Perform experimental combustion research in an optically accessible engine with alternative fuel blends, including DME and Fisher Tropsch diesel provided by the Office of Fossil Energy; examine fuel injection spray characteristics and study formation of NOx and soot. Develop chemical kinetic models to simulate the combustion of alternative fuel/diesel fuel blends in a diesel engine. Continue development of a three-way catalyst to reduce NOx in the exhaust stream of natural gas fueled engines. Evaluate projected heavy vehicle emissions inventories for NOx, volatile organic compounds, toxics, and particulates. Using modeling and other techniques, examine the potential future atmospheric impacts on urban air quality and climate change from heavy vehicle emissions. Continue

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Alternative Fuels R&D (Cont'd)	additional projects that match DOE goals of identifying relative alternative fuel impacts on air quality. Conducted research on health issues associated with new engine technologies.	urban airshed modeling emphasizing the relative impacts of heavy vehicles operating on alternative fuels and fuel blends compared to petroleum-based diesel. Conduct cooperative program with the Office of Energy Research to evaluate the health impacts of diesel engine particulates from alternative fuels and alternative fuel blends.	cost-shared research with the Coordinating Research Council, California Air Resources Board, and other organizations on studies of mutual interest. Continue a cooperative program with the Office of Energy Research to evaluate the health impacts of diesel engine particulates from alternative fuel blends. Examine the chemical interactions between ozone and particulates in urban atmospheres.
	Engine R&D: Initiated an effort in partnership with the Gas Research Institute, California's South Coast Air Quality Management District, and the Trucking Research Institute in support of a natural gas enhanced engine efficiency program. Evaluated three ignition assist concepts in support of direct injection diesel cycle operation on natural gas. Completed a proof-of-concept testing of common rail fuel injection system for DME fuel.	Engine R&D: Award contracts to kickoff the natural gas enhanced engine efficiency program. Continue development of advanced natural gas engines with the goal of raising efficiency levels to that of their petroleum-based diesel fueled counterparts. Integrate the flexible fuel engine concept with the low emission (LE)-55 engine family, incorporating its efficiency and emissions goals. Study the capability of advanced technologies, including variable valve timing, to expand the fuel tolerance of the diesel engine and enable greater fuel flexibility. Perform reliability assessment	Engine R&D: Continue the natural gas enhanced engine efficiency program with the goal of reaching the technology targets of the LE-55 engine. Continue development of LE-55 engine technology to enable this concept to be fuel flexible on liquid alternative fuels and blends. Conduct round robin emissions, performance, and durability testing of the best available engine technologies operating on alternative fuel/diesel fuel blends. Complete phase three, on-road test, of conformable natural gas tank. Conduct research activities aimed at developing natural gas tank technologies that fully

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Alternative Fuels R&D (Cont'd)		studies for heavy vehicles on the components comprising liquefied natural gas (LNG) storage. Continue development and testing of advanced LNG storage systems for heavy vehicles. Complete certification testing of conformable-shaped CNG tanks and burst test low pressure tanks, thus completing phase two and allowing on-road testing to begin.	integrate the fuel dispenser, the tank, and the engine system. Develop smart sensor technology to enable the monitoring of natural gas tank structural integrity on a continuous basis, utilizing technology developed for the Department of Defense in the DOE Defense Program. Continue development of advanced LNG storage and fuel delivery systems to support direct injected natural gas engine technology. Develop technology to support compressor development for adsorbent natural gas storage. Conduct research aimed at developing a high efficiency, small-scale natural gas compressor/fuel delivery system. Cost share effort with the Office of Fossil Energy to support the La Porte facility in tailoring fuel quality of DME and Fisher Tropsch diesel toward the LE-55 fuel requirements.
	Advanced Development: Tested 150 heavy duty trucks and buses with the West Virginia University (WVU) transportable chassis dynamometer. Used the capability of this equipment to	Advanced Development: Continue advanced development of alternative fueled engine/vehicle systems, with the goal of bringing newly developed natural gas and propane	Advanced Development: Continue activities with West Virginia University and the Trucking Research Institute to support the advanced development of heavy duty

III. Performance Summary: ADVANCED HEAVY VEHICLE TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Alternative Fuels R&D (Cont'd)	perform iterative testing and advanced development of vehicle engine systems operating on natural gas. Prepared case study on medium duty alternative fuel demonstration vehicles.	technologies to production-ready status. Continue the operation of the West Virginia University Transportable Chassis Dynamometer, utilizing its capabilities as a developmental tool.	alternative fuel technologies.
	(NREL, ORNL, ANL, BDM, WVU, SwRI) ($12,159)	(NREL, SNL, ORNL, BNL, ANL, Caterpillar, Detroit Diesel Corp., WVU, SwRI) ($12,700)	(NREL, PNNL, SNL, ORNL, BNL, ANL, Caterpillar, Detroit Diesel Corp., WVU, SwRI) ($11,000)
	$12,159	$ 12,700	$ 11,000
Advanced Heavy Vehicle Technologies Total	$ 19,129	$ 25,600	$ 44,200

TRANSPORTATION TECHNOLOGIES

TRANSPORTATION SECTOR
(dollars in thousands)

TRANSPORTATION MATERIALS TECHNOLOGIES

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission

Timely availability of new materials and materials manufacturing technologies is critical for the development and engineering of advanced transportation vehicles. The materials R&D required for transportation vehicles falls into three categories: (1) Automotive Materials Technology, (2) Heavy Vehicle Materials Technology, and (3) the High Temperature Materials Laboratory. An important element of the Transportation Materials Technologies program is the partnership between Federal government laboratories and U.S. industry, which ensures that the R&D is relevant and that Federal research dollars are highly leveraged.

The Automotive Materials Technology program develops: (a) propulsion system materials to enable advanced propulsion systems for hybrid vehicles, and (b) lightweight vehicle materials to reduce weight and thereby decrease fuel consumption and carbon emissions. The program's objective is to develop advanced materials with the required properties, and the processes needed to produce them at the costs and volumes required by the automotive producers. Improved materials and processes for advanced engine, fuel cell, and electrical powertrain components are critical to attaining target efficiencies and automotive costs. Improved materials for body, chassis, and powertrain are critical to attaining the challenging performance and fuel economy goals for advanced automotive vehicles. By 2004, as part of the Partnership for a New Generation of Vehicles (PNGV) initiative, advanced automotive materials technology should be available which will ensure that the weight of light duty vehicles can be reduced by 40 percent compared to the 1994 PNGV baseline and that the powertrain can achieve energy conversion efficiencies sufficient to meet the 80 miles per gallon target.

The Heavy Vehicle Materials Technology program focuses on two areas: (a) heavy vehicle propulsion, and (b) high strength weight reduction materials. In collaboration with U.S. industry and universities, heavy vehicle propulsion system materials efforts focus on the materials technologies critical to the development of diesel engines for light trucks, vans, and sport utility vehicles, as well as the low emissions, 55 percent efficient (LE-55) heavy duty diesel engine for heavy trucks. These include thick thermal barrier coatings and insulating structural ceramics, advanced fuel system materials, materials for nitrogen oxides (NOx) and particulate reduction, advanced air handling materials, and smart materials (i.e., materials that can change their properties as a function of how they are used) for fuel injection systems. The design of advanced components for high efficiency diesel engines has, in some cases, pushed the performance envelope for materials of construction past the point of reliable operation. Higher mechanical and surface stresses and higher temperatures of advanced designs limit the engine designer; advanced materials allow the design of components that may operate reliably at higher stresses and temperatures, thus enabling more efficient engine designs. Advanced materials also offer the

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

opportunity to improve the emissions; noise, vibration, and harshness (NVH); and performance of diesel engines for pickup trucks, vans, and sport utility vehicles. In the area of high strength weight reduction materials, energy savings from commercial trucking is possible with high strength materials which can reduce the vehicle weight within the existing envelope, so as to increase payload capacity, and thereby reduce the number of trucks needed on the highways. Increased safety can be obtained from new brake materials and by incorporating high shock absorbent materials in truck structures for improved control and crashworthiness.

The High Temperature Materials Laboratory (HTML), at the Oak Ridge National Laboratory, is a modern research facility that houses in its six user centers a unique collection of instruments for characterizing materials. It supports a wide variety of high temperature ceramics and metals R&D. The HTML enables scientists and engineers to solve materials problems that limit the efficiency and reliability of advanced energy conversion systems by providing access to sophisticated state-of-the-art equipment which few individual companies and institutions can afford to purchase and maintain.

I. B. Program Benefits

Metric	2000	2010	2020
Primary Energy Displaced (Quads)			
Primary Oil Displaced (million barrels per day)	Benefits for Transportation Materials Technologies are included in the benefits for Advanced Automotive Technologies and Advanced Heavy Vehicle Technologies		
Energy Cost Savings ($ billion)			
Carbon Reductions (million metric tons)			

I. C. Performance Measures

Automotive Materials Technology:

Strategy/Goal: By 2004, in partnership with U.S. automotive manufacturers and suppliers, enhance the materials technology base available to ground transportation vehicle manufacturers to enable high efficiency advanced propulsion systems and a weight reduction of 40 percent in automobiles, compared to a 1995 baseline.

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

FY 1997 Accomplishments

-- Developed an aluminum alloy which requires no heat treatment, with cost equivalent to or less than currently used grades of aluminum sheet.

-- Improved reliability of small, lightweight metal castings by 10 percent and reduced the rejection rate by more than 25 percent.

-- Demonstrated scale-up production of ceramic gas turbine nozzles at 200 parts/month, with greater than 50 percent total process yield.

-- Demonstrated preform processing for rapid preforming of glass fiber reinforced composites.

-- Initiated R&D for improved, low cost, lightweight bipolar plate material, coordinating efforts with fuel cell components R&D under Advanced Automotive Technologies.

FY 1998 Planned Accomplishments

-- Perform prototype testing of lightweight vehicle components with a production cost of 1.1 times the cost of conventional materials.

-- Identify R&D for low cost production of lower weight magnesium components for chassis applications, thus increasing the amount of magnesium in cars by 50 percent.

-- Identify key material properties and processing improvements for advanced power electronic materials for hybrid vehicle applications, coordinating activities with Advanced Power Electronics program under Advanced Automotive Technologies.

-- Validate 50 percent lower cost aluminum sheet processing technology, as compared to cost of ingot-to-sheet technology.

-- Conclude R&D on automotive gas turbine ceramics, and transition program to support the remaining 80 mpg propulsion system candidates.

FY 1999 Planned Accomplishments

-- Produce prototype carbon fiber reinforced polymer composites for body panel applications using carbon fiber reduced in cost by 80 percent.

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

-- Initiate R&D on methods for low cost production of titanium, to increase its use in chassis and powertrain components by 50 percent.

-- Demonstrate low cost casting methods to produce structural light metal castings for automotive applications.

-- Validate, by manufacturing demonstrations and modeling, cost competitive processing of advanced compression ignition direct injection (CIDI) and fuel cell propulsion system materials and components, in conjunction with Advanced Automotive Technologies programs.

FY 2000 - FY 2004 Planned Accomplishments

-- Develop low cost advanced materials and novel methods of processing to meet the design requirements of high efficiency advanced heat engines.

-- Fabricate a prototype large automotive structure using carbon fiber reinforced polymer composites, with realistic cycle times and realistic system costs, and perform barrier testing to assess its energy absorption characteristics.

Heavy Vehicle Materials Technology:

Strategy/Goal: Focus on the diesel engine. In partnership with the diesel engine manufacturers, truck manufacturers, and their material and component suppliers, develop cost effective material technologies for enabling fuel flexibility and heavy vehicle fuel economy.

FY 1997 Accomplishments

-- Demonstrated a ten-times reduction in cost, and improvement in quality, of diesel engine ceramic components such as valves, fuel injector plungers, and turbocharger rotors.

-- Sintered 1,000 silicon nitride engine valves in a continuous furnace, and finished five sets for in-service heavy duty engine testing.

-- Proceeded to optimize the forming process (e.g., casting and aggregate squeeze casting) for high strength lightweight materials for heavy vehicles.

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

FY 1998 Planned Accomplishments

-- Complete zirconia-ceramic materials and precision manufacturing development for high pressure/rate-shaping fuel injector components.

-- Complete 500-hour thermal fatigue rig durability testing of thick thermal barrier coatings for piston-crown insulation.

-- Reduce heavy vehicle weight by 1,250 lbs. through substitutions with high strength lightweight materials.

-- Develop a multi-year program plan for the development of lightweight rigid structures for pickups, vans, and sport utility vehicles, as well as the larger Class 7-8 over-the-road trucks, through the Northwest Alliance for Transportation Technologies (NATT).

FY 1999 Planned Accomplishments

-- Develop technologies to manufacture thick thermal barrier coated pistons for the 55 percent efficient (LE-55) engine with an incremental cost increase acceptable to the customer; demonstrate over 2,000 hours durability.

-- Demonstrate a reliable and commercially viable cylinder head insert for the advanced LE-55 engine, made from a suitable ceramic (zirconia toughened mullite) using innovative composite and sintering processes.

-- Develop new catalyst systems which include plasma assisted catalysis, and determine if microwave systems coupled with catalysts can reduce the activation energy required for NOx catalysts.

-- Develop material systems that increase turbocharger design flexibility and improve variable geometry turbocharging. Demonstrate cost effective and reliable shaft attachments for titanium aluminide (TiAl) rotors, as well as reliable and durable variable geometry actuation methods.

-- Complete system development of fuel injection systems actuated by "smart" material systems, including electro-hydro-mechanical modeling, combustion optimization, and materials selection.

-- Complete development of the process for casting ultra large vehicular components; cast prototypes for laboratory testing and evaluation by original equipment manufacturers (OEMs); field test qualified components under service conditions.

-- Extend the successful development of metal compression forming for solid solution and precipitation hardenable aluminum alloys to metal matrix composites and magnesium alloys. Produce prototype components for testing and evaluation by OEMs.

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

-- Complete the characterization of coal-derived carbon fibers for weight reduction applications in heavy vehicles.

-- Reduce heavy vehicle weight by an additional 750 lbs. through substitutions with high strength lightweight materials, for a total vehicular weight reduction of 2,000 lbs.

-- Implement a planned program through the Northwest Alliance for Transportation Technologies (NATT) to reduce the weight of heavy trucks and pickups, vans, and sport utility vehicles.

FY 2000 - FY 2004 Planned Accomplishments

-- Complete the several cooperative agreements with the three major U.S. diesel engine manufacturers and their suppliers, to develop enabling materials technology for low emissions, higher efficiency diesel engines. Complete engine evaluations of components which have potential for introduction into diesel engines.

-- In conjunction with the heavy vehicle industry, define and test the design, methodological, materials, process, and forming approaches required to cost effectively achieve further total heavy vehicle weight reduction of 5,000 pounds; validate the maintenance of safety and vehicular performance requirements in all applicable truck classifications.

-- Optimize and implement the successful approaches, in discrete stages, to achieve the ultimate total vehicular weight reduction of 5,000 pounds in the Class 7-8 truck classifications, and of realistic appropriate weight reductions in the intermediate truck classifications.

High Temperature Materials Laboratory (HTML):

Strategy/Goal: Support industry, government, and university efforts in high temperature materials research through a state-of-art research facility and user centers.

FY 1997 Accomplishments

-- Increased from 3 to 10 the number of industrial users in the residual stress user center funded jointly between DOE's Offices of Energy Efficiency and Renewable Energy and Energy Research.

-- Implemented country-wide remote access to HTML equipment for users via the Internet.

I. Mission Supporting Goals and Objectives: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

FY 1998 Planned Accomplishments

-- Establish facilities for evaluating material performance under high thermal gradients, including thermal shock and cyclic oxidation of thermal barrier coatings.

-- Add radiography, tomography, and temperature measurement inside running engines to neutron-based characterization capabilities.

FY 1999 Planned Accomplishments

-- As part of DOE 2000, provide neutron instruments for user residual-stress measurements, at the High Flux Isotope Reactor, on the remote access network.

-- Expand capability for x-ray stress measurement on curved surfaces by use of parallel beam optics.

-- Demonstrate an intelligent grinding process for ceramic engine components, and demonstrate manufacturing of products such as engine valves and fuel injector components.

II. A. Funding Table: TRANSPORTATION MATERIALS TECHNOLOGIES

Program Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Automotive Materials Technology	$ 19,997	$ 21,750	$ 19,000	$ -2,750	-13%
Heavy Vehicle Materials Technology	7,702	8,050	7,300	-750	-9%
High Temperature Materials Laboratory ...	4,557	5,200	5,500	300	6%
Total, Transportation Materials Technologies	$ 32,256	$ 35,000	$ 31,800	$ -3,200	-9%

II. B. <u>Laboratory and Facility Funding Table</u>: TRANSPORTATION MATERIALS TECHNOLOGIES

	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Ames Lab	$ 150	$ 65	$ 65	$ 0	0%
Argonne National Lab (East)	1131	380	744	364	96%
Idaho National Engineering and Environmental Lab	1,498	700	2,000	1,300	186%
Lawrence Livermore National Lab	886	1,000	1,000	0	0%
Los Alamos National Laboratory	665	1,005	805	-200	-20%
National Renewable Energy Lab	21	0	0	0	0%
Oak Ridge National Lab	18,625	22,683	21,743	-940	-4%
Pacific Northwest National Lab	3,750	2,205	1,205	-1,000	-45%
Sandia National Laboratories	1,205	650	650	0	0%
All Other	4,325	6,312	3,588	-2,724	-43%
Total, Transportation Materials Technologies	$ 32,256	$ 35,000	$ 31,800	$ -3,200	-9%

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES

Activity	FY 1997	FY 1998	FY 1999
Automotive Materials Technology	PROPULSION MATERIALS: Continued the development of advanced materials and analytical design tools, along with associated manufacturing technologies needed to enable achieving the goal of significantly increasing the fuel economy of propulsion systems for automobiles. Demonstrated scale-up production of ceramic vanes and blades for a commercial gas turbine auxiliary power unit. Initiated follow-on program to demonstrate low cost manufacturing of complex automotive ceramic gas turbine components in larger quantities. Improved ceramic-metal joining technologies for heat engine assemblies. Continued characterization of time-dependent high temperature deformation behavior of candidate heat engine materials. Investigated integration of engine design, materials, and coatings to reduce engine friction and improve noise, vibration and harshness characteristics while maintaining or improving durability and cost. (ORNL, NASA Lewis, AlliedSignal	PROPULSION MATERIALS: Conclude R&D on automotive gas turbine ceramic materials and processes. Effect an orderly and cost effective transition of these laboratory in-house and contracted ceramics projects to a broader advanced materials R&D program that supports targeted improvements in efficiency and automotive manufacturing cost for the remaining Partnership for a New Generation of Vehicles (PNGV) candidate propulsion systems: compression ignition direct injection (CIDI) engine, fuel cell, and complementary propulsion electronics and electric machines. Coordinate the transition with the Office of Heavy Vehicle Technologies (OHVT), and Office of Industrial Technologies (OIT) propulsion/turbine materials activities. Prepare, with OIT, for an orderly transfer of those automotive gas turbine ceramic technology projects needed for continued support of the industrial gas turbine program. Assume responsibility for and continue development of low cost bipolar plate material systems for	PROPULSION MATERIALS: Continue enabling R&D efforts on advanced materials in support of, and in close coordination with, PNGV candidate propulsion systems development. The propulsion systems include advanced energy conversion, power control and transmission, and emission control concepts and components for the remaining candidates: CIDI engines and fuel cells, with associated electro-mechanical power trains. Continue to develop and validate materials having characteristics, such as high strength, high temperature performance, low friction, highly magnetic, highly insulating or conducting (heat or electricity), and durability. These materials include advanced metals, plastics, ceramics, composites, and new concepts. Analyze automotive scale manufacturing processes to form low cost components using these materials. Evaluate specific new materials concepts. (ORNL, ANL, LANL, ONR, Universities, Contractors, TBD) (PNGV: $3,000) ($3,000)

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Materials Technology (Cont'd)	Ceramics, AlliedSignal Engines, Univ. of Dayton Research Institute, Univ. of Michigan, Kyocera Industrial Ceramics, ONR) (PNGV: $6,381) ($6,381)	fuel cells. Broaden non-gas turbine ceramics and other propulsion materials R&D efforts, such as ultra low friction coatings, microwave regenerated particulate trap matrices, and advanced material systems for power capacitors and electronic substrates. (ORNL, AlliedSignal Ceramics, Kyocera Industrial Ceramics, Univ. of Dayton Research Institute, Univ. of Michigan, NASA Lewis; ANL, LANL, Nixdorf, ONR, TBD) (PNGV: $6,500) ($6,500)	
	LIGHTWEIGHT MATERIALS: The goals of the lightweight vehicle materials program are to successfully design and prototype lighter automotive structural components. A cooperative industry-government management structure, involving the United States Automotive Materials Partnership (USAMP) and the PNGV Materials Technical Team, collaboratively set technical targets and jointly established R&D priorities with DOE.	LIGHTWEIGHT MATERIALS: Continue establishing priorities for R&D efforts in conjunction with USAMP and PNGV Materials Technical Team.	LIGHTWEIGHT MATERIALS: Continue establishing priorities for R&D efforts in conjunction with USAMP and PNGV Materials Technical Team.
	Metals: Continued R&D to develop and verify high volume,	Metals: Maintain efforts to develop and verify high volume	Metals: Develop low cost cast light metals for structural chassis

III. Performance Summary: **TRANSPORTATION MATERIALS TECHNOLOGIES** (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Materials Technology (Cont'd)	low cost aluminum sheet production methods for automotive body and structural applications. Developed improved processes such as semi-solid forming for thin-wall precision casting of magnesium and aluminum alloys, and reduced cost metal matrix composites.	low cost aluminum sheet production and joining methods for automotive body and structural applications. Maintain efforts to develop improved, recyclable aluminum alloys for weight reduction, with fewer processing steps at lower costs. Complete assessments to determine R&D for low cost magnesium and titanium components, for chassis and engine applications.	applications. Adapt innovative technologies for the production, forming, and recycling of low cost aluminum sheet for automotive body panels and structures. Initiate R&D on promising technologies to lower the cost of titanium and magnesium in automotive chassis and powertrain applications. Continue R&D to further develop low cost, light metal alloys and metal matrix composite processing technologies.
	Composites: Verified capability of meeting automotive requirements with carbon and carbon/glass fiber reinforced polymer composites. Assessed high volume production processes, weight, cost, crash worthiness, recyclability, durability, and repairability.	Composites: Continue efforts to develop low cost polymer composites for structural applications. Initiate, with USAMP, efforts to accelerate availability of low cost carbon fiber for high strength composite components by advancing processing improvements. To reduce current manufacturing costs, implement rapid prototyping approaches for lightweight automotive polymer components.	Composites: Continue R&D on low cost carbon fiber for polymer matrix composites. Identify techniques to integrate these new fibers into advanced resins using innovative composite processing methods.
	Developed and demonstrated reliable joining methods for dissimilar automotive materials,	Continue efforts on joining methods and NDT of joints.	Continue R&D on joining methods and NDT of joints.

III. Performance Summary: **TRANSPORTATION MATERIALS TECHNOLOGIES** (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Materials Technology (Cont'd)	to lower the cost of vehicular assembly and assure safety of joints. Included in-plant non-destructive testing (NDT) of mechanical, adhesive, and fusion joints.		
	In conjunction with fuel cell program, initiated R&D to develop lightweight bipolar plate materials for fuel cell applications.	Continue activity under Propulsion Materials.	
	Established the Northwest Alliance for Transportation Technologies. (ORNL, PNNL, Ames Lab, SNL, INEEL, LANL, LLNL, LBNL, Univ. of Texas-Austin, Alcoa, Commonwealth Aluminum, Ravenswood Aluminum, Ford, Chrysler, GM, Reynolds Aluminum, Textron, Rockville, Knight & Packer, Budd Corp., Amcast, Georgia Tech, Purdue Univ., Applicator System, Oakland Univ., Concurrent Tech., ARCO Aluminum, Thixomat) (PNGV: $13,616) ($13,616)	Identify efforts to be supported by the Northwest Alliance for Transportation Technologies. Issue request for proposals, select contractors, and initiate work. (ORNL, PNNL, Ames Lab, SNL, INEEL, LANL, LLNL, LBNL, Univ. of Texas-Austin, Alcoa, Chrysler, Ford, GM, Reynolds Aluminum, Commonwealth Aluminum, Ravenswood Aluminum, Textron, Rockwell, Knight & Packer, Budd Corp., Amcast, Georgia Tech, Purdue Univ. Applicator System, Oakland Univ., Concurrent Tech., ARCO Aluminum, Thixomat) (PNGV: $15,250) ($15,250)	Continue to support the Northwest Alliance for Transportation Technologies projects to develop advanced low-cost materials for transportation. (PNNL, ORNL, Ames Lab, SNL, INEEL, LANL, LLNL, LBNL, ALRC, University of Texas-Austin, ALCOA, Reynolds Metals, Chrysler, Ford, GM, Commonwealth Aluminum, Ravenswood Aluminum, Textron, Rockwell, Budd Company, Amcast, ARCO Aluminum, Thixomat, Georgia Tech, Oakland University, University of Michigan, Michigan Tech, Erie Press Systems, Troy Design,

III. Performance Summary: **TRANSPORTATION MATERIALS TECHNOLOGIES** (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Automotive Materials Technology (Cont'd)			Imageware, AutoDie International, Wyman Gordon, Universal Energy Systems, Eck Industries, CMI International, Thompson Aluminum Casting, Stackpole, EPRI, Inland Bar Steel, Republic Engineered Steel, North Star Steel Co., MacSteel Co., Aeroquip Corp., Stahl Speciality, Westmorland Mechanical Testing, Delphi Energy Systems, PACCAR) (PNGV: $16,000) ($16,000)
	$ 19,997	$ 21,750	$ 19,000
Heavy Vehicle Materials Technology	HEAVY VEHICLE PROPULSION SYSTEM MATERIALS: Expanded materials development to include both ceramics and other materials needed by the heavy vehicle propulsion system manufacturers and suppliers for low emissions, high efficiency diesel engine components. Initiated 50% cost-shared cooperative agreements with U.S. engine manufacturing companies, to research and develop materials for heavy duty and multi-purpose	HEAVY VEHICLE PROPULSION SYSTEM MATERIALS: Develop advanced materials technologies that contribute to the achievement of 55% efficiency in diesel engines (LE-55) for heavy vehicles, while simultaneously reducing emissions of environmental pollutants to meet increasingly stringent standards. Expand the application of the materials technologies under development to include diesel engines for multipurpose vehicles	HEAVY VEHICLE PROPULSION SYSTEM MATERIALS: Continue work in partnership with the diesel engine companies and suppliers to develop enabling materials technology for low emission, higher efficiency diesel engines. Verify 2,000 hour durability of thick thermal barrier coating using component thermal fatigue rig, and continue engine testing to verify the 10,000 hour durability required for highway truck application of LE-55 technology.

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Materials Technology (Cont'd)	diesel engines. Developed thick thermal barrier coatings and insulating structural ceramics, advanced fuel system materials, materials for nitrogen oxides (NOx) and particulate reduction, advanced air handling materials, and materials for high brake mean effective pressure (BMEP) engines. Completed the advanced ceramic manufacturing program by demonstrating ten times reduction in cost, with improved quality, for ceramic diesel engine components, including valves, fuel injector plungers, clevis pins, and turbocharger rotors. Sintered 1,000 silicon nitride engine valves in continuous furnaces. Demonstrated scalability of microwave processing of ceramic heat engine components to commercial heavy vehicle quantities. Developed low cost powder for fabricating low expansion ceramics. Certified new generation diamond grinding wheels for high speed grinding of ceramic components. Extended life prediction methodology to include failure mechanisms observed for piston engines. Completed transfer of information	(100-275 horsepower) that account for a rapidly growing market segment (pickups, vans, and sport utility vehicles). Continue R&D on cost effective, high toughness silicon nitride for diesel components; expand Cooperative Research and Development Agreement (CRADA) activity with industry. Develop alumina matrix, self-lubricating ceramics for low cost/low emission valve guides. Continue low expansion materials development and catalyst characterization using the High Temperature Materials Laboratory electron microscopes. Continue life prediction verification of engine valve materials. Complete the ceramic machining efforts. Continue support of low cost sintering, and CRADA-directed non-destructive testing. Continue diesel component manufacturing technology projects with industry that support efficient diesel engine objectives. These include development of titanium aluminide and other materials for more efficient turbocharger rotors, ceramic thermal barrier	Through 50% cost-shared agreements with the three leading U.S. diesel companies: (1) continue development of a zirconia toughened mullite cylinder head insert for advanced diesel engines, using composite fabrication and low cost processing; (2) continue projects on fuel system materials, materials for NOx and particulate reduction, advanced airhandling materials, and materials for higher cylinder-pressure engines; and (3) develop "smart materials" for fuel injection systems; this is a revolutionary approach using a piezoceramic actuator to allow greater speed and control for fuel injection rate shaping. Continue non-destructive evaluation (NDE) of diesel engine materials; high temperature tensile testing and life prediction of ceramic valves; ceramic materials testing standards activities, jointly with industry and standard setting organizations. Continue support to a Historically Black University's Center for Advanced Materials and Smart Structures. In partnership with the Office of Fossil Energy's liquefaction

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Materials Technology (Cont'd)	to the Internet. (ORNL, Saint-Gobain Norton, Kyocera, Cummins Engine, Caterpillar, Detroit Diesel, LoTEC, Eaton Corp. North Carolina AT&T, Univ. of Massachusetts, NIST, ANL) ($4,925)	piston and cylinder head coatings, ceramic exhaust port and intake port liners, wear resistant liner coatings, and smart material actuators. Initiate tribology (friction, wear and lubrication) applied research. (ORNL, Cummins Engine, Caterpillar, Detroit Diesel Corp., LoTEC, Southern Illinois Univ., Univ. of Massachusetts, ANL) ($4,950)	program, support characterization of fuel processing catalysts utilizing unique High Temperature Materials Laboratory (HTML) capabilities. Coordinate all activities with Automotive Materials Technology program. (ORNL, Caterpillar Inc., Cummins Engine Co., Detroit Diesel Corp., North Carolina A&T State Univ., ANL, NIST) ($6,300)
	HIGH STRENGTH WEIGHT REDUCTION MATERIALS: Developed high rate (greater than 1 per 5 minutes) process for casting large, lightweight, high strength, reliable, cost competitive vehicular components. Performed test casts on prototype to define casting parameters.	HIGH STRENGTH WEIGHT REDUCTION MATERIALS: Cast selected large, high strength, light weight vehicular components by a high rate process, to validate selection of casting parameters and prepare for industrial production run.	HIGH STRENGTH WEIGHT REDUCTION MATERIALS: Complete large component castings project. In conjunction with West Virginia University (WVU) and the Office of Fossil Energy, continue to develop, characterize, and test precursor fibers, and other forms of coal-derived carbon, for light weighting of heavy vehicle components, such as structural insulation, tires, and safety applications. In cooperation with the Northwest Alliance for Transportation Technologies, and DOE's Offices of Industrial Technologies and Energy Research, evaluate applications of new metal forming processes and
	Evaluated the potential use of carbon-based materials in commercial vehicular applications requiring improved stiffness, durability, and lighter weight, as a function of cost and process. (Alcoa, Thompson Aluminum Casting, Cummins Engine Co., Amoco, Detroit	Fabricate and test selected prototype components employing carbon-based materials for heavy vehicle applications, based on improved stiffness, durability and lighter weight. Complete development and characterization of advanced	

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Heavy Vehicle Materials Technology (Cont'd)	Diesel Corp., Caterpillar Tractor, ORNL, ANL, PNNL, WVU, MIT) ($2,777)	processing of high strength, lightweight materials for heavy vehicle engine and structural applications. Continue development and characterization of lightweight metallic components for application in advanced diesel engines. (American Trucking Associations, truck OEMs, ALCOA, Thompson Aluminum Casting, Cummins Engine Co., Amoco, Detroit Diesel Corp., Caterpillar Tractor, ORNL, PNNL, WVU, MIT) ($3,100)	lightweight alloys for producing heavy vehicle components, particularly structural and advanced diesel engine applications. Coordinate all activities with Automotive Materials Technologies program. (American Trucking Associations, truck OEMs, Alcoa, Thompson Aluminum Casting, Cummins Engine Co., Amoco, Detroit Diesel Corp., Caterpillar Inc., ORNL, ANL, PNNL, WVU, MIT) ($1,000)
	$ 7,702	$ 8,050	$ 7,300
High Temperature Materials Laboratory	HTML OPERATION: With the unique collection of instruments in six HTML user centers, provided a comprehensive set of tools for performing state-of-the-art determination of the structure and properties of materials at high temperatures. Provided funding to fully support 17 scientific staff for the user program, and increase collaborative activities with	HTML OPERATION: The HTML is a nationally-designated user facility comprising a building of about 64,500 square feet in which reside six user centers that are made available to American industries and universities to help solve materials problems. Each user center is focused on a suite of specialized instruments and techniques, with the staff to	HTML OPERATION: With the unique collection of instruments in the six HTML user centers, continue to provide a comprehensive set of tools for performing state-of-the-art determination of the structures and properties of materials at high temperature. Provide increasingly sophisticated instrumentation and techniques, including microstructure at higher

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
High Temperature Materials Laboratory (Cont'd)	industry in the joint EE/ER residual stress user center.	operate them. Continue to focus HTML support and assistance to automotive manufacturers, heavy vehicle manufacturers, diesel engine manufacturers, and the trucking industry. Provide funding to fully support 16 scientific staff for the user program.	resolution, IR (infra-red) imaging of processes at their sites, thermal barrier and other coating evaluation (hardness, modulus, thermal properties, wear, friction, residual stresses, adherence), ceramic component lifetime analysis, and higher speed/higher precision machining. Fully support 16 scientific staff for the user program.
	Demonstrated remote microscopy between an industrial user and ORNL, using software at the industrial site that operates an electron microscope. Developed unique capabilities to image, at high resolution, both electrostatic and magnetic fields in semiconductor materials, and in free space using electron holographic techniques. Established facilities for evaluating material performance under high thermal gradients, including thermal shock and cyclic oxidation of thermal barrier coatings. Added capabilities in the area of micro mechanical characterization of materials. Increased industrial user days to 3,900. (ORNL) ($4,557)	As part of the DOE 2000 initiative, increase applications of the remote operation technique, developed in prior years for the electron microscopes, by applying to other instruments. Increase efforts to provide users with friction and wear characterization capabilities. Demonstrate neutron radiography and tomography for large items such as engine blocks. Demonstrate remote capability (DOE 2000) via neutron resonance spectrometry, to accurately measure temperatures of components, such as pistons, in operating diesel or other internal combustion engines. (ORNL) ($5,200)	Continue participation in the DOE 2000 Materials Micro Characterization Collaboratory (MMC), an Office of Energy Research initiative with Heavy Vehicle Materials and HTML participation and funding. The MMC is designed to permit creative scientists, having varying yet complementary expertise, to operate in a new environment which allows convenient, rapid, and dynamic research interactions to flow unencumbered by the limits of time and distance. Purchase a high resolution Scanning Auger Microscope, which has 10 times the brightness, and 10 times the signal, of the current instrument.

III. Performance Summary: TRANSPORTATION MATERIALS TECHNOLOGIES (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
High Temperature Materials Laboratory (Cont'd)			Maintain existing equipment and upgrade the Differential Scanning Calorimeter. ($5,500)
	$ 4,557	$ 5,200	$ 5,500
Transportation Materials Technologies Total	$ 32,256	$ 35,000	$ 31,800

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(dollars in thousands)

TECHNOLOGY DEPLOYMENT

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission

This program's mission is to reduce oil consumption, as well as environmental emissions, through promoting the introduction and commercialization of alternative fuel vehicles (AFVs) and advanced technology vehicles with significantly improved fuel economy.

During and following successful technology development by industry and government, and in coordination with partners, stakeholders, and customers, this program provides the catalyst needed to establish an improved public understanding about, and resulting market demand for, alternative fuel vehicles, advanced technology vehicles, and advanced fuels; and establish a strong and far-reaching fuel and service infrastructure. The program is designed to provide support at critical periods in the transition of advanced transportation technologies from the laboratory to the marketplace, and then reduce government support as market penetration improves for vehicles which reduce petroleum consumption.

The Energy Policy Act of 1992 (EPACT) establishes multiple goals for alternative fuel technology development and utilization. Fuels of interest include biodiesel, electricity, ethanol, hydrogen, methanol, natural gas, and propane. Relative to petroleum fuel substitution, the basic EPACT goal is to promote the development and use of domestic replacement fuels to substitute for imported petroleum motor fuels to the maximum extent practicable. Within the context of the basic program goal, DOE focuses its program on those replacement fuels which will have the greatest impact on: reducing oil imports, improving the nation's economy, and reducing criteria pollutants and greenhouse gas emissions.

Achieving these goals will require the establishment of sustainable alternative fuel and vehicle production industries, and extensive private sector investment in supporting infrastructure. Markets for the products of these industries will be based on the confidence of consumers in the performance, reliability, cost-effectiveness, and other characteristics of those products. This program is about building that confidence by weaving together a variety of activities in response to customer needs. The program will:

- ✓ Forge partnerships with fleet owners, fuel providers, vehicle manufacturers, and State and local governments to expand the use of alternative fuel vehicles and the development of refueling infrastructure.
- ✓ Provide current, accurate, reliable information on all types of alternative fuels and vehicles.
- ✓ Perform rigorous, structured programs to test and evaluate cars and trucks that use alternative fuels.

I. Mission Supporting Goals and Objectives: TECHNOLOGY DEPLOYMENT (Cont'd)

- ✓ Implement the requirements of the Energy Policy Act.
- ✓ Promote consumer acceptance of advanced technology cars and trucks with significantly improved fuel economy.

With fleets paving the way for higher volume, lower cost vehicle production, and the installation of refueling capability, the objective is to make alternative fuel vehicles the choice of many individual private vehicle purchasers by the year 2000. Local, voluntary initiatives and agreements can be the mechanism by which all parties with a stake in alternative fuels can develop their plans together. With this premise, DOE has created and nurtured the Clean Cities program. Clean Cities is a voluntary Federal program designed to accelerate and expand the use of alternative fuel vehicles (AFVs) in communities throughout the country, and to provide refueling and maintenance facilities for their operation. As of January 1998, sixty communities have joined the Clean Cities program. Clean Cities encourages local governments and organizations to form public/private partnerships in developing markets for AFVs. Many of these local programs have links across regional and State boundaries to establish Clean Corridors with refueling infrastructure to allow inter-city travel with alternative fuel vehicles.

Under provisions of the Alternative Motor Fuels Act of 1988 and EPACT, a large number of vehicles are included in the Department of Energy's data acquisition activities. These vehicles represent a comprehensive cross section of our national commercial fleet. Projects are cost shared with many industry, State, and Federal groups. These activities place state-of-the-art AFV technology "on the road" for real-world fleet test evaluation. Over 1,000 Federal and commercial sedans, pickup trucks, vans, minivans, snowplows, garbage trucks, long-haul trucks, school buses, and urban mass transit buses have been tracked continuously, with performance, fuel economy, emissions, and maintenance data provided to the DOE-sponsored Alternative Fuels Data Center for compilation, analysis and dissemination.

To assist with utilization activities and provide information, fact sheets and reports designed to describe the various projects currently underway within the Office of Transportation Technologies (OTT) are developed. The distribution of the Congressionally-mandated Fuel Economy Guide, a pamphlet developed to help consumers compare the fuel economy of similarly sized new cars and light trucks, is made available to all new vehicle dealerships and to persons and organizations which request copies.

I. B. Program Benefits

	2000	2010	2020
Primary Energy Displaced (Quads)	0	0	0
Primary Oil Displaced (million barrels per day)	0.05	0.40	0.45
Energy Cost Savings ($ billion)	0.34	2.49	1.80
Carbon Reductions (million metric tons)	0.46	3.98	4.47

Using the quality metrics modeling methodology, it is estimated that 500,000 AFVs will be in operation nationally by the year 2000, thereby displacing 50,000 barrels per day of petroleum, reducing carbon emissions by 0.46 million metric tons per year, and reducing annual energy costs (i.e., oil costs) by approximately $340 million per year.

I. **Mission Supporting Goals and Objectives**: TECHNOLOGY DEPLOYMENT (Cont'd)

I. C. Performance Goals

Strategy/Goal: In concert with regional and local authorities, partnerships will be created among fuel suppliers, vehicle manufacturers, and fleet operators to displace 50,000 barrels per day of petroleum by the year 2000. This represents an annual savings of approximately $340 million in energy (oil) costs, and will lay the groundwork for further expansion of the alternative fuels industry and continued reduction in imported petroleum products.

FY 1997 Accomplishments

-- Expanded the Clean Cities program to 57 participating communities, and expanded efforts to help communities develop local market development plans for alternative fuels.

-- Initiated field test/evaluation of electric vehicles using the first generation of advanced batteries developed under the Department of Energy's (DOE) cooperative agreement with the U.S. Advanced Battery Consortium.

-- Completed Phase I of public/private development of an alternative fuel clean corridor linking California, Nevada, and Utah. Initiated Phase I of a similar program for the New York-Philadelphia-Baltimore-Washington, D.C., corridor.

-- Reviewed public comments on Energy Policy Act fleet programs, and incorporated them into a technical and policy analysis of the Act's replacement fuel goals, for submission to Congress.

FY 1998 Planned Accomplishments

-- Expand Clean Cities program to 60 participating communities and focus efforts on assisting implementation of local plans for alternative fuel market development.

-- Strengthen infrastructure corridor program, through the States and Clean Cities, that will encourage refueling development and alternative fuel use.

-- Complete field test/evaluation of electric vehicles using first generation advanced batteries developed with support from the DOE/U.S. Advanced Battery Consortium.

-- Add electric and hybrid vehicle data and information products to the Alternative Fuels Data Center and disseminate through Clean Cities.

I. Mission Supporting Goals and Objectives: TECHNOLOGY DEPLOYMENT (Cont'd)

-- Through the Clean Cities program, continue to attract alternatively fueled medium and heavy duty urban delivery vehicle fleets as key urban stakeholders.

-- Initiate efforts to promote technologies to reduce greenhouse gases through Clean Cities grants.

-- Close out certification of training program and transition to private sector.

-- Continue implementation of EPACT fleet requirements, with emphasis on adding 10,000 AFVs to the Federal fleet and undertaking a rulemaking to consider expanding requirements to private and local fleets.

FY 1999 Planned Accomplishments

-- Expand Clean Cities scope to include emphasis on greenhouse gas reductions, significantly expanding grants to States and Clean Cities to demonstrate vehicles with significantly improved fuel economy.

-- Improve the value of the Fuel Economy Guide and other information products, as a means to encourage the use of fuel efficient vehicles.

-- Demonstrate state-of-the-art, fuel-efficient vehicle technologies for cars and trucks, including hybrid vehicles.

-- Link and solidify Clean Cities infrastructure and corridor investments launched in 1996 through 1998, creating continuous corridors of alternative fuel infrastructure linking 10 major urban centers.

-- Determine, through public comment and rulemaking, how to modify the Energy Policy Act replacement fuel goals, and design a program to promote the maximum practicable use of alternative fuels.

-- Continue EPACT fleet programs, adding 15,000 AFVs to the Federal fleet and completing the rulemaking on private and local fleets.

FY 2000 - FY 2004 Planned Accomplishments

-- Support a national Clean Cities Foundation to support and coordinate the network of local coalitions.

-- Implement focused projects that reduce greenhouse gases through the use of advanced technologies and low greenhouse gas fuels.

-- Increase utilization of advanced hybrid and electric vehicles.

-- Facilitate the use of 500,000 alternatively fueled vehicles operating in the Clean Cities and corridors.

II. A. Funding Table: TECHNOLOGY DEPLOYMENT

Program Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Clean Cities Voluntary Deployment	$ 2,606	$ 2,850	$ 6,000	$ 3,150	111%
Infrastructure, Systems, and Safety	1,605	2,175	2,000	-175	-8%
EPACT Replacement Fuels Program	1,475	1,400	1,300	-100	-7%
Vehicle Field Test/Evaluation	2,432	2,850	3,450	600	21%
Technical Information Development	2,500	2,500	3,500	1,000	40%
Total, Technology Deployment	$ 10,618	$ 11,775	$ 16,250	$ 4,475	38%

II. B. Laboratory and Facility Funding Table: TECHNOLOGY DEPLOYMENT

Argonne National Lab (East)	$ 1,055	$ 950	$ 950	$ 0	0%
Idaho National Engineering and Environmental Lab	482	660	1,460	800	121%
National Renewable Energy Lab	3,332	2,410	2,410	0	0%
Oak Ridge National Lab	375	200	200	0	0%
All Other	5,374	7,555	11,230	3,675	49%
Total, Technology Deployment	$ 10,618	$ 11,775	$ 16,250	$ 4,475	38%

III. Performance Summary: TECHNOLOGY DEPLOYMENT

Activity	FY 1997	FY 1998	FY 1999
Clean Cities Voluntary Deployment	Supported voluntary programs for State and local governments and private industry to acquire alternative fuel vehicles in 57 participating Clean Cities through developing and using expanded networks and agency-to-agency communications. Expanded coordinated efforts with the electric utility industry to introduce electric vehicles in selected Clean Cities, catalyzed infrastructure development and encouraged consumer acceptance. (EPACT Section 505) (NREL)	Expand the Clean Cities program to at least 60 participating communities, focusing efforts to leverage specific private capital investments for greater alternative fuel market development. Continue efforts to measure the success of each city in carrying out its plan. Voluntary private sector efforts complement existing rules for government fleets and help to meet energy, environmental, and economic goals. Strengthen and expand electric vehicle programs started in Clean Cities during the EV Market Launch. (EPACT Section 505) (NREL)	Strengthen the Clean Cities program through focus on infrastructure and corridor efforts, supported by increased funding for projects to address market barriers. Expand Clean Cities scope to encompass reductions in greenhouse gases as well as other emissions of concern. Develop tools and training to promote use of fuel efficient and advanced technology vehicles. (EPACT Section 505) (NREL)
	Linked grants to State governments for accelerated use of alternative fuel vehicles with the Clean Cities Program. (EPACT Section 409)	Continue State grants work from previous year with an emphasis on infrastructure development. (EPACT Section 409)	Increase State grants work from previous year. Expand projects that deliver reductions in air emissions, including greenhouse gases. (EPACT Section 409)
	Continued demonstration and evaluation of alternative fuel cars and trucks, working with selected States and Clean Cities. (EPACT Section 302) (INEEL, States) $2,606)	Cost share demonstration and evaluation of light and heavy duty alternative fuel vehicles with industry, focusing on new applications in selected Clean	Expand cost-shared demonstrations from previous year, adding advanced technology, fuel-efficient vehicle demonstrations, such as hybrid vehicles, in Clean Cities.

III. <u>Performance Summary</u>: TECHNOLOGY DEPLOYMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Clean Cities Voluntary Deployment (Cont'd)		Cities. (EPACT Section 302) (INEEL, States) ($2,850)	(EPACT Section 302) (INEEL, States) ($6,000)
	$ 2,606	$ 2,850	$ 6,000
Infrastructure, Systems, and Safety	Completed Phase I of the public/private development of an alternative fuel clean corridor linking California, Nevada, and Utah, as part of the Clean Cities program. (EPACT Section 505)	Commence Phase II of a nationwide infrastructure corridor development program, through the Clean Cities and States, to encourage private investment in refueling development along key transportation corridors. (EPACT Sections 505 and 502)	Continue work from previous year, with an additional focus on deployment projects that reduce greenhouse gases and other air emissions through the use of advanced technology and low carbon fuels. Use some grant funds to begin a National Parks initiative. (EPACT Sections 505 and 502)
	Continued certification of training programs for alternative fuel technicians to provide broad coverage of all alternative fuels. (EPACT Section 411) (NATEF)	Close out certification of training program and transfer to private sector. (EPACT Section 411) (NATEF)	
	Continued work with electric utilities and the Infrastructure Working Council on coordinated development of electric vehicle infrastructure. (EPACT Sections 505 and 601) (INEEL)	Continue work with electric utilities from previous year. (EPACT Sections 505 and 601) (INEEL)	Continue work with electric utilities on electric vehicle infrastructure. (EPACT Sections 505 and 601) (INEEL)

III. <u>Performance Summary</u>: TECHNOLOGY DEPLOYMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Infrastructure, Systems, and Safety (Cont'd)	Expanded systems and safety analysis of refueling, transport, and delivery infrastructure for alternative fuels. (EPACT Section 502) (INEEL) ($1,605)	In coordination with industry, further refine systems and safety analysis of refueling, transport, and delivery infrastructure for alternative fuels, and implement findings as appropriate. (EPACT Section 502) (INEEL) ($2,175)	Continue infrastructure systems and safety analysis from previous years, with focus on compressed and liquified natural gas. (EPACT Section 502) (INEEL) ($2,000)
	$ 1,605	$ 2,175	$ 2,000
EPACT Replacement Fuels Program	Utilized analytical tools to assess the EPACT replacement fuel goals and solicited public comment on programs to reach the goals. Added modeling capability for analysis of transition pathways for alternative fuels. (EPACT Section 502) (ANL, ORNL)	Using transition modeling and other analytical tools, assess progress of EPACT fleet programs in helping to reach the Act's replacement fuel goals. Develop utilization scenarios for advanced transportation technologies, such as hybrid and fuel cell vehicles, that draw upon Clean Cities experience and industry expertise. (EPACT Section 502) (ANL, ORNL, TBD)	Continue analytical and modeling work to support EPACT rulemakings. Expand scenarios to include the Partnership for a New Generation of Vehicles (PNGV) and new heavy vehicle technologies. (EPACT Section 502) (ANL, ORNL, TBD)
	Reviewed public comment on EPACT fleet programs and incorporated in a technical and policy analysis of the Act's replacement fuel goals. (EPACT Sections 506 and 507) (ORNL)	Obtain additional public comment on the potential for additional fleet programs, renewable fuels, replacement fuels, and incentive programs to meet the Act's goals and reduce vulnerability to oil price shocks. Use comments to	Obtain public comment on the second technical and policy analysis of the Act's replacement fuels goals and submit to the President and Congress. (EPACT Sections 506 and 507) (ORNL)

III. <u>Performance Summary</u>: TECHNOLOGY DEPLOYMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
		initiate a second technical and policy analysis of the Act's goals. (EPACT Sections 506 and 507) (ORNL)	
EPACT Replacement Fuels Program (Cont'd)	Continued implementation of the credit trading program for State and fuel provider compliance with EPACT mandates. (EPACT Sections 501, 507 and 508) (NREL, ANL, ORNL)	Continue EPACT regulatory work, initiating rulemaking on private and local fleets. (EPACT Sections 501, 507 and 508) (NREL, ANL, ORNL)	Continue regulatory work on alternative fuels and fleet programs including completion of rulemaking on private and local fleets. (EPACT Sections 501, 507, and 508) (NREL, ANL, ORNL) ($1,300)
	In cooperation with industry, developed and issued, as needed, guidance, standards, and regulations for alternative fuel composition. (EPACT Section 302) (ANL)	Complete standards work from previous year. (EPACT Section 302) (ANL)	
	Continued transportation demand management program in selected Clean Cities to develop tools and technologies to increase efficiency in the transportation sector in coordination with DOE and EPA. (EPACT Sections 502(a) and 504) ($1,475)	Transition demand management efforts to Clean Cities program. (EPACT Sections 502(a) and 504) ($1,400)	
	$ 1,475	$ 1,400	$ 1,300

III. <u>Performance Summary</u>: TECHNOLOGY DEPLOYMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Vehicle Field Test/Evaluation Vehicle Field Test/Evaluation (Cont'd)	Emissions testing program re-engineered to reduce emissions and performance testing on General Services Administration alternative fuel vehicles. Expanded efforts to collect data from private fleets and developed case studies of fleet experience with alternative fuels. (NREL, ANL)	Focus light duty alternative fuel vehicle emissions and performance testing on small numbers of new original equipment manufacturer and qualified vehicle modifier vehicles. Continue work from previous year. (NREL, ANL)	Continue fuel and vehicle emissions testing and coordinate with electric vehicle field test and evaluation efforts. (NREL, ANL)
	With modified program, initiated testing and evaluation of new electric vehicles to support commercialization in response to the requirements of EPACT. Initiated field test/evaluation of electric vehicles with first generation advanced batteries. (EPACT Sections 601 and 505) (INEEL) ($2,432)	Acquire, test, and evaluate new electric vehicles to support commercialization in response to the requirements of Executive Order 13031. Continue work from previous year. (EPACT Sections 601 and 505) (INEEL) ($2,850)	Start field testing hybrids developed under the Partnership for a New Generation of Vehicles (PNGV). Continue to acquire, test, and evaluate new electric vehicles to support commercialization in response to the requirements of Executive Order 13031. Continue work from previous year. (EPACT Sections 601 and 505) (INEEL) ($3,450)
	$ 2,432	$ 2,850	$ 3,450
Technical Information Development	Streamlined publication and distribution of the congressionally required Fuel Economy Guide. (GPO)	Continue publication of Fuel Economy Guide. (GPO)	Re-engineer the Fuel Economy Guide and develop other consumer products for Clean Cities and consumers to promote fuel efficiency, advanced

III. <u>Performance Summary</u>: TECHNOLOGY DEPLOYMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Technical Information Development (Cont'd)	Working with stakeholders, continued to develop technical information on alternative fuels for various audiences. Expanded the delivery mechanisms for these products to ensure that affected audiences have access to the information. Continued to use DOE regional support offices to disseminate documents and publications. (EPACT Sections 302 and 405) (ANL, NREL, ORNL) ($2,500)	Through EPACT information programs, provide targeted technical information products to fleets and other stakeholders. Provide information over the Internet, at conferences, and through publications. Continue work from previous year. (EPACT Section 405) (ANL, NREL, ORNL) ($2,500)	technology vehicles and low greenhouse gas technologies. Continue technical information development, adding products related to near-term PNGV technologies, including fuel cells. (EPACT Section 405) (ANL, NREL, ORNL) ($3,500)
	$ 2,500	$ 2,500	$ 3,500
Technology Deployment Total	$ 10,618	$ 11,775	$ 16,250

TRANSPORTATION TECHNOLOGIES
TRANSPORTATION SECTOR
(dollars in thousands)

IMPLEMENTATION AND PROGRAM MANAGEMENT

I. Mission Supporting Goals and Objectives:

I. A. Statement of Mission

Implementation and Program Management supports the human resource requirements as well as the Office-level analysis, assessment, evaluation, and planning functions for the Office of Transportation Technologies (OTT). The mission of the program is to provide the integrated program direction needed to plan, manage, and oversee the research, development, and technology deployment activities funded by the transportation sector program. The analytical and evaluation part of the mission is accomplished by collecting and analyzing technology and market data, using computer models to project technology potential and market share, and calculating program benefits.

The technology assessment activity estimates the impacts, benefits, and costs of advanced transportation vehicle and fuel technologies. A system of models has been created that: (1) estimates the market shares of new light duty vehicle sales for alternative advanced vehicle technologies; and (2) calculates the alternative fuel use, petroleum use reductions, and changes in ambient and global emissions. These models are continually being improved and updated to consider new technology developments, and to be consistent with projections prepared by the Energy Information Administration. The models are also being used to estimate the impacts of individual technology programs during budget formulation and program planning.

The analysis function produces the annual Transportation Energy Data Book; assembles the best past and current data to use in updating transportation sector plans; and supports preparation and updating of Energy Efficiency and Renewable Energy and Department of Energy plans.

I. B. Performance Goals

FY 1997 Planned Accomplishments

-- Began development of a light and heavy vehicle benefits model jointly with the Energy Information Administration.

-- Improved the accuracy of the vehicle choice models by taking capital constraints and model-turnover rates into account.

I. Mission Supporting Goals and Objectives: IMPLEMENTATION AND PROGRAM MANAGEMENT (Cont'd)

FY 1998 Planned Accomplishments

-- Continue to improve the quality metrics methodology to incorporate risk and uncertain future oil prices.

FY 1999 Planned Accomplishments

-- Expand the quality metrics methodology to include international impacts. This will include estimating the benefits for domestic manufacturers of selling advanced technologies abroad and the impact of foreign manufacturers introducing technology to the U.S.

- Undertake a major effort to estimate the cost of advanced vehicle technologies, with emphasis on the cost of vehicles capable of achieving 80 miles per gallon.

FY 2000 - FY 2004 Planned Accomplishments

-- Update all the computer model coefficients, especially the vehicle choice coefficients.

II. A. **Funding Table**: IMPLEMENTATION AND PROGRAM MANAGEMENT

Program Activity	FY 1997 Enacted	FY 1998 Enacted	FY 1999 Request	$ Change	% Change
Evaluation, Planning and Analysis	$ 1,700	$ 1,700	$ 2,500	$ 800	47%
Program Direction	6,037	5,900	6,700	800	14%
Total, Implementation and Program Management	$ 7,737	$ 7,600	$ 9,200	$ 1,600	21%

II. B. **Laboratory and Facility Funding Table**: IMPLEMENTATION AND PROGRAM MANAGEMENT

Argonne National Lab (East)	$ 1,100	$ 1,000	$ 1,200	$ 200	20%
National Renewable Energy Lab	250	240	200	-40	-17%
Oak Ridge National Lab	300	340	300	-40	-12%
All Other	6,087	6,020	7,500	1,480	25%
Total, Implementation and Program Management	$ 7,737	$ 7,600	$ 9,200	$ 1,600	21%

III. Performance Summary: IMPLEMENTATION AND PROGRAM MANAGEMENT

Activity	FY 1997	FY 1998	FY 1999
Evaluation, Planning and Analysis	Maintained a comprehensive and accurate set of transportation data, including energy use by transportation mode and fuel type. Prepared baseline projections of future transportation demands and energy use, and estimated the petroleum savings and substitution potential of transportation programs. Published and distributed Edition 17 of the Transportation Energy Data Book; expanded information to include alternative vehicle registration and fuel use. Assessed the energy, environmental, and economic impacts of introducing new vehicles and fuels. Estimated the oil substitution and energy saving impacts of all the technology programs for alternative funding levels, fuel price scenarios, and economic growth scenarios. Estimated technology market penetration by operating improved vehicle and fuel choice models. Developed detailed technology characterization of alternative vehicle technologies as input to the choice models. Completed total energy cycle analysis for hybrid vehicles, addressing several battery types, propulsion engine and fuel types. Initiated a comparative total energy cycle analysis that deals with all the alternative vehicle and fuel	Continue to maintain a comprehensive and accurate set of transportation data, including energy use by transportation mode and fuel type. Assemble baseline projections of future transportation demands and energy use, and estimate the petroleum savings and substitution potential of transportation programs, as well as the pollution and economic impacts. Publish and distribute Edition 18 of the Transportation Energy Data Book; expand to include detailed information on the growth of light truck use. Assess the energy, environmental, and economic impacts of introducing new vehicles and fuels. Estimate the oil substitution and energy saving impacts of all the technology programs for alternative funding levels, and scenarios for fuel price and economic growth. Estimate technology market penetration by operating the vehicle and fuel choice models that have been improved. Develop detailed technology characterization of alternative vehicle technologies as input to the choice models. Complete the total energy cycle analysis for all alternative vehicles and fuels. Initiate a comparative total energy cycle analysis for fuel cell vehicles. (ANL, ORNL, NREL, TBD) ($1,700)	Continue to maintain a comprehensive and accurate set of transportation data, including energy use by transportation mode and fuel type. Assemble baseline projections of future transportation demands and energy use. Estimate the petroleum savings, oil substitution potential, emissions reduction and economic impacts of transportation programs. Publish and distribute Edition 19 of the Transportation Energy Data Book. Continue to assess the energy, environmental, and economic impacts of introducing new vehicles and fuels. Estimate the oil substitution, energy saving impacts, and emissions reduction of all the technology programs for alternative funding levels, fuel price scenarios, and economic growth scenarios. Estimate technology market penetration by operating the vehicle and fuel choice models. Develop detailed technology characterization of alternative vehicle technologies as input to the choice models. Complete the comparative total energy cycle analysis for fuel cell vehicles. Analyze the international impacts of exporting and/or importing advanced vehicle technologies. Improve methods for estimating greenhouse gas reductions from travel

III. <u>Performance Summary</u>: IMPLEMENTATION AND PROGRAM MANAGEMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Evaluation, Planning and Analysis (Cont'd)	technologies. (ANL, ORNL, NREL) ($1,700)		demand reductions, land use planning, and telecommunications. Analyze the market for greenhouse gas reducing technologies. The level of these efforts also increase commensurate with the base program level. (ANL, ORNL, NREL, TBD) ($2500)
	$ 1,700	$ 1,700	$ 2,500
Program Direction	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $4,702 12.1 Civilian personnel benefits $ 931 21.0 Travel and transportation of person $ 251 25.2 Other services $ 153 Provided funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support the 68 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (67) and in the field (1). ($6,037)	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $4,382 12.1 Civilian personnel benefits $898 21.0 Travel and transportation of persons $ 450 25.2 Other services $ 170 Provide funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support the 61 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (60) and in the field (1). A 3% contingency is provided under Other Services. ($5,900)	The following is a breakdown of the funding by Object Class: 11.9 Personnel compensation $4,264 12.1 Civilian personnel benefits $ 936 21.0 Travel and transportation of persons $ 450 25.2 Other services $1,050 Provide funds for salaries, benefits, and travel (including normal increases in both salaries and benefits) to support 58 FTEs needed to conduct and monitor research, development, and other activities associated with various transportation technologies, at Headquarters (57) and in the field (1). A total of $1,050 under Other Services includes activities such as permanent change of station moves, employee training, and a 5% contingency. ($6,700)

III. Performance Summary: IMPLEMENTATION AND PROGRAM MANAGEMENT (Cont'd)

Activity	FY 1997	FY 1998	FY 1999
Program Direction (Cont'd)	$ 6,037	$ 5,900	$ 6,700
Implementation and Program Management Total	$ 7,737	$ 7,600	$ 9,200